FINAL REPORT
SEPTEMBER 30, 2023

Bird Island Creation in Carancahua Bay

A Project of the Coastal Management Program Contract: 22-045-002-D099

Prepared by: Alexis Baldera
Senior Manager, Coastal Program
Audubon Texas
Alexis.baldera@audubon.org

This report was funded in part by a Texas Coastal Management Program grant approved by the Texas Land Commissioner, providing financial assistance under the Coastal Zone Management Act of 1972, as amended, awarded by the National Oceanic and Atmospheric Administration (NOAA), Office for Coastal Management, pursuant to NOAA Award No. NA21NOS4190136. The views expressed herein are those of the author(s) and do not necessarily reflect the views of NOAA, the U.S. Department of Commerce, or any of their subagencies.

Royal and Sandwich Terns on Chester Island.
Photo: Peggy Wilkinson/Audubon Texas

Project Background

The Matagorda Bay (the Bay) complex is the third largest estuarine system on the Texas coast. Historically, the Bay has supported abundant bird populations. Over the past few decades nesting numbers in the region have declined steadily, largely due to the conversion of nesting sites to open water by severe erosion and relative sea level rise. Because of this decline, scientists and conservationists have recognized the need for enhanced bird habitat in the region. The National Audubon Society (Audubon) is proposing to build a new bird rookery island at the mouth of Carancahua Bay in Calhoun County, Texas.

For this project funded by CMP Cycle 26 funds Audubon prepared the engineering, design, and permitting for a new bird rookery island at the mouth of Carancahua Bay. Specifically, Audubon completed 100% of the engineering and design of a two to four-acre island, submitted a Section 404 permitting with a Nationwide Permit 27 application to the US Army Corps of Engineers (USACE), and submitted a GLO Surface Lease for the construction of the island. Prior to the engineering, design, and permitting work Audubon completed additional wave and hydrodynamic modeling to understand the marine environment near two potential island sites. Audubon also incorporated input from stakeholders through a meeting of experts familiar with the site or bird island construction and integrated that information into the final design.

Audubon envisions that increased bird populations will occur within two to five years following island construction. Ground-nesters such as Black Skimmers, Terns, American Oystercatchers, and shrub-nesters such as Herons, Egrets, Roseate Spoonbills, and Neotropic Cormorants will benefit from the island construction. This project will also lead to economic benefits, because the Texas coast is a premier location for birders, anglers, and outdoor enthusiasts.

Phase I

Task 1: Hydrodynamic and Wave Modeling

The project was split into two phases, with the second phase contingent on GLO approval of the first phase. The first phase included completing Task 1 to determine if the project would have negative impacts on the nearby shoreline and past or ongoing shoreline projection projects. As Audubon began the modeling work with Freese and Nichols, Inc. (FNI) and a subcontractor, US Fish and Wildlife Service (USFWS) suggested adding two or more sites to the analysis. Suggestions included an island near the mouth of Redfish Lake in Carancahua Bay and a new site north of Schicke Point within the Bay. The island near the mouth of Redfish Lake is privately owned so was not further considered through this project. Instead, and in response to this request, Audubon added the site north of Schicke Point within the Bay. This second site was included in the wave and hydrodynamic analysis. FNI and subcontractor Dr. Rusty Feagan (Texas A&M University), modeled the hydrodynamics and wave conditions of two different island designs (i.e., round and linear) at two sites (Map 1). The purpose of the modeling was to investigate the effects of potential island structures on waves, current flow velocities, and current directions. The results showed that: (1) all alternatives did not measurably affect waves or flow velocities near existing soft sediment shorelines or existing structures, (2) all alternatives provided some wave protection immediately next to the designed structures, but relatively minimal protection to Schicke Point, (3) structures placed inside the mouth of Carancahua Bay reduced flow velocities more than those recessed inside of it, on average, and round structures reduced them more than linear ones, (4) structures recessed inside Carancahua Bay produced less risk to altering the inlet exchange patterns than structures placed near its mouth, although the overall risk is relatively low. FNI provided the following conclusion about their interpretation of the modeling results:

> *Our surveys and modeling suggest that it would be feasible to construct a productive rookery in Matagorda Bay at both sites: north of Schicke Point and at the mouth of Carancahua Bay. The proposed locations meet Audubon Texas' goal and are considered suitable locations for the following reasons:*
>
> - *Physical conditions at the two proposed locations indicate that island construction is feasible. Surface substrate within the areas of interest was firm sand. Poling of the bay bottom suggests its*

ability to support an island. The bottom characteristics indicate costs to keep an island from sinking into the bottom will be much lower than if the bottom was soft silt or organic muck.

- *The area of interest around the Carancahua Bay mouth has an average depth of less than 3 feet at Mean Sea Level (MSL). The area of interest at the north Schicke Point location is 3 to 4 feet deep at MSL. The shallow nature of the area means that much less material would be required to build the island than if it were in waters 5 to 6 feet deep.*
- *Field observations and data review showed no evidence of oysters or sea grass within the two locations. Field sampling also showed there were no accumulations of shell in the two areas of interest that would be buried by a new island. Impacts to oysters, sea grass, or shell bottom are not expected.*
- *Hydrodynamic modeling was conducted to evaluate the effects of waves and currents on the island and surrounding shorelines, particularly at Redfish Lake Island and Schicke Point. Modeling determined that there would be minimal impacts to the surrounding shorelines from the proposed island. To compensate for potential erosive currents and tides to the rookery island, all island designs feature armoring on all sides to reduce wave and current erosion.*
- *To prevent terrestrial predators and nuisance odors, the Audubon technical advisory committee recommended that islands be sited at least 0.2 miles from land. The proposed location at the Carancahua Bay mouth is approximately 0.3 miles from Schicke Point. The north Schicke Point location is 0.67 miles from the Schicke Point community. The distance from the mainland may discourage terrestrial predators from swimming to the island. The prevailing southeasterly winds would blow nuisance odors from the island away from the Schicke Point community.*
- *Lastly, both locations are physically accessible for both construction equipment and for biological monitoring after construction. Shallow-draft barges with rock and excavators can access the area through the Matagorda Ship Channel and Carancahua Bay mouth. There is a public boat ramp in Port Alto in Carancahua Bay, approximately 3.5 to 4 miles from the proposed locations.*

In addition to reviewing the model results, Audubon also gathered stakeholder input to further evaluate the potential success of the proposed island sites. Local stakeholders raised concerns that the site within the Bay, north of Schicke Point, was in an area of high recreational use. The modeling report and a summary of our stakeholder input is included in Appendix A. After reviewing the modeling results, stakeholder input, and the feasibility studies we determined that the site at the mouth of Carancahua Bay was the preferred site to consider for permitting and design of a bird island. The General Land Office sent a letter of permission to Audubon on April 1, 2022 which initiated phase 2 of the project.

Map 1. The two sites evaluated for bird island feasibility. Site 1 shown in red is the site Audubon chose to move forward to phase 2.

Phase II

Task 2: Field Surveys and Designs

Audubon released a Request for Qualifications, received and reviewed one proposal, and selected FNI for the second phase of the project. After contracting was complete work began on Phase II in September 2022. In addition to selecting an engineering firm, Task 2 included subtasks for an oyster and seagrass habitat survey and an archaeological survey if required during the US Army Corps of Engineers (USACE) permitting process. Marine survey plans were submitted to the GLO for review by NOAA during the first phase of the project. After submitting the permit applications described in Task 3, a marine archeological survey was required by USACE. While waiting for a response from NOAA to approve or deny the marine survey plans Audubon heard feedback from partners that there were concerns about the project location and feasibility. In collaboration with the GLO, Audubon decided to reallocate funds for the marine surveys to host a stakeholder input meeting to determine if concerns from partners and the community could be alleviated. The marine surveys were removed from the project due to 1) concerns about the timeliness of NOAA's review, and 2) more pressing concerns from interested stakeholders. Audubon convened and facilitated a meeting in Palacious (August 2023) with partners at USFWS, TPWD, GLO, and Matagorda Bay Foundation. During the meeting FNI went into detail about the different steps of the analysis and feasibility study to-date. The meeting also included discussion of remaining questions about the potential bird islands impact on shorelines, alternative sites in need of restoration around the bay, and additional interested community members. During the meeting there was also a request by the USFWS to complete a geotechnical review before finalizing the designs. The detailed meeting notes, additional follow-up input, and an attendee list are included in Appendix B.

Task 3: Permits

The draft Nationwide Permit 27 (NWP 27): Aquatic Habitat Restoration, Enhancement, and Establishment Activities Pre-construction Notification (PCN) application for the construction of a rookery island with a total overall footprint of 2.7 acres at the mouth of Carancahua Bay was submitted to Audubon (Alexis Baldera) by FNI on February 23, 2023, for review and signature. The final compiled permit application was submitted to the U.S. Army Corp of Engineers (USACE): Galveston District for evaluation on March 1, 2023.

The Carancahua Bay Mouth Rookery Island project permit application was assigned to Ms. Kayla Roberts as the USACE District Engineer on March 6, 2023. The USACE has reviewed the permit application and determined that the permit area was likely to yield archeological sites. On March 22, 2023, the USACE recommended that a marine archeological survey be performed to assess the presence of artifacts within the project area.

Audubon and FNI received a proposal from Bob Hydrographics, LLC. for a marine archeological survey magnetometer and sonar data, as requested by USACE. Because of the nature of the CMP grant, Audubon was not authorized to begin marine surveys until specific marine survey plans and methodologies are submitted to satisfy the requirements of NEPA. As described in Task 2 Audubon decided to host a stakeholder meeting during the project timeframe and the marine surveys through a separate source at a later date.

Task 4: Site Design

FNI designed the proposed bird island through four phases of design: 30 percent, 60 percent, 90 percent, and 100 percent. The final design is included as Appendix C and is for a bird island with a total footprint of 2.7 acres that would be sited at the mouth of Carancahua Bay. The island is designed to have both upland vegetated habitat for tree and shrub nesters and sloping shoreline habitat for beach nesters. The species targeted are Tricolored Heron, Roseate Spoonbill, Snowy Egret, Reddish Egret, Black-crowned Night Heron, Least Tern, Forster's Tern, Black Skimmer, and American Oystercatcher.

Details from the 90 percent design report specify that “The rookery island shall consist of an island constructed to an elevation of +6 feet NAVD88 and an armor layer to reduce erosive forces, per criteria set in Feasibility Study. An aerial view of the island is shown in Figure 5. Island fill shall consist of in-situ sediment dredged from a nearby borrow source that the GLO TxSed database has shown contains primarily gravel and sand (GLO 2023). These assumptions will be confirmed through geotechnical soil testing.

The island consists of two armor sections that include a breakwater and revetment. The breakwater is designed with a crest elevation of +6 feet NAVD88, crest width of 3 feet, and side slopes of 2:1 (H: V), see Figure 6. The revetment is designed to crest elevation of +6 feet NAVD88 with a minimum crest width of 3.9 feet, slope of 2:1 (H: V) and minimum launchable toe width of 3.9 feet, see Figure 7. The median stable armor stone size was calculated to be approximately 1.3 feet in diameter resulting in approximate armor stone minimum thickness of 3 feet to achieve a minimum of two diameters thickness.” The referenced figures and the full 90 percent design report are included as Appendix C. The final 100% design will be submitted with the full report. The island is estimated to cost around $4 million to build. Audubon has applied to the GLO’s project of special merit program to fund the construction and monitoring of the proposed bird island.

Appendix A: Stakeholder Input and Modeling Report

Island Building in Carancahua Bay Project

Stakeholder input summary
Audubon Texas
March 30, 2022

Informed by the Matagorda Bay Texas Rookery Island Feasibility Study and Alternatives Analysis report (Nichols, Inc., 2018) funded by the NFWF Gulf Environmental Benefit Fund, Audubon Texas is evaluating three locations for adding new bird nesting islands in the Matagorda Bay region. One of which is at the mouth of Carancahua Bay where two sites have been identified as suitable to support the creation of a new rookery island. In addition to evaluating the physical conditions at the site, Audubon Texas is evaluating stakeholder input and local knowledge of the sites. In December 2020, Audubon posted signs at the Schicke Point Marina announcing our intent to evaluate sites for island creation and asked for input from the community. Through this effort we did not receive any comments. After completing wave and current modeling analysis in January 2022 Audubon directly shared results with and gathered input from community members. In this second round of stakeholder input Audubon heard the following comments about the northern most site (site two on map below):

1. Concern that the location and prevailing wind direction near site two will generate foul odors for residents in the Schicke Point area;
2. Potential interaction with recreational uses because site two is in an area that is popular for water skiing and boating; and
3. Concerns that the island would experience human disturbance during holiday weekend. During Memorial Day and Fourth of July holidays large groups of boaters are known to congregate on beaches on the bay side of Schicke point. This area is near where site 2 is located and there are concerns boaters will also land on the constructed island.

Based on the expected size of the island and distance from shore, Audubon feels strongly that the foul odors will not be an issue for the Schicke Point community. However, the interaction with recreational uses in the bay has the potential to jeopardize nesting at site two. Human disturbance of nesting birds is known to cause nest abandonment and can lead to reduced reproductive success. These concerns are shared by Audubon Texas, and we prefer the site at the mouth of Carancahua Bay (site one) for further consideration as a bird nesting island.

Map. Sites evaluated for bird island feasibility.

Modeling Report

Carancahua Rookery Study

Project ABD21908
Phase Code 0001
Task Code 0AI0

Subconsultant: Rusty A. Feagin, Ph.D.

Executive Summary

We simulated four alternatives for a Bird Rookery Island in Carancahua Bay. The purpose was to investigate the effects of potential design structures on waves, current flow velocities, and current directions. The result show that: (1) All alternatives do not measurably affect waves or flow velocities near existing soft sediment shorelines or existing structures, (2) All alternatives provide some wave protection immediately next to the designed structures, but relatively minimal protection to Schicke Point, (3) Structures placed inside the mouth of Carancahua Bay reduce flow velocities more than those than those recessed inside of it, on average, and round structures reduce them more than linear ones, (4) Structures recessed inside Carancahua Bay produce less risk to altering the inlet exchange patterns than structures placed near its mouth, although the overall risk is relatively low.

Methods

We placed the 4 alternatives within an existing and publicly available Delft3d flexible mesh model created by Texas A&M University (TAMU) for the Texas General Land Office (GLO). This model was extensively parameterized and validated using field datasets. Its inputs include:

- wind speed and direction (from NOAA Port Lavaca station #8773259)
- temperature (from NOAA Port Lavaca station #8773259)
- verified water level (from NOAA Port Aransas station #8775241, with calibrated offsets)
- freshwater inflow (from USGS gauges for Lavaca River using the Edna station #0816400, Colorado River using the Colorado RV station #08162501, Tres Palacios River using Tres Palacios RV station #08162600, and Tres Palacios RV*0.5 for Carancahua)
- terrestrial surface elevations (from FEMA/TWDB LIDAR datasets)
- bathymetry (from a field-collected GLO/TAMU dataset at high resolution for the Carancahua Bay inlet area, embedded within a coarser resolution dataset from NOAA)

To place the 4 alternatives into Delft3d, we first re-projected the FNI-provided shapefiles into UTM NAD83 Zone 14N meters. We then converted the lines into polygons and filled them with points at 5 m spacing, such that the points were all 10 m in height. We then imported these points into Delft3d, overlayed them with the existing bathymetry, and re-interpolated the bathymetry. This embedded the structures into the local bathymetry such that they were immovable.

We then simulated waves and flow, and their interactions with the alternatives, over a time period from January to July 2020, at hourly time steps. For each model run, we compared the alternative with a baseline “no structure” scenario.

Fig. 1. Example of the Delft3D mesh spacing around the alternatives, and throughout the simulated basin.

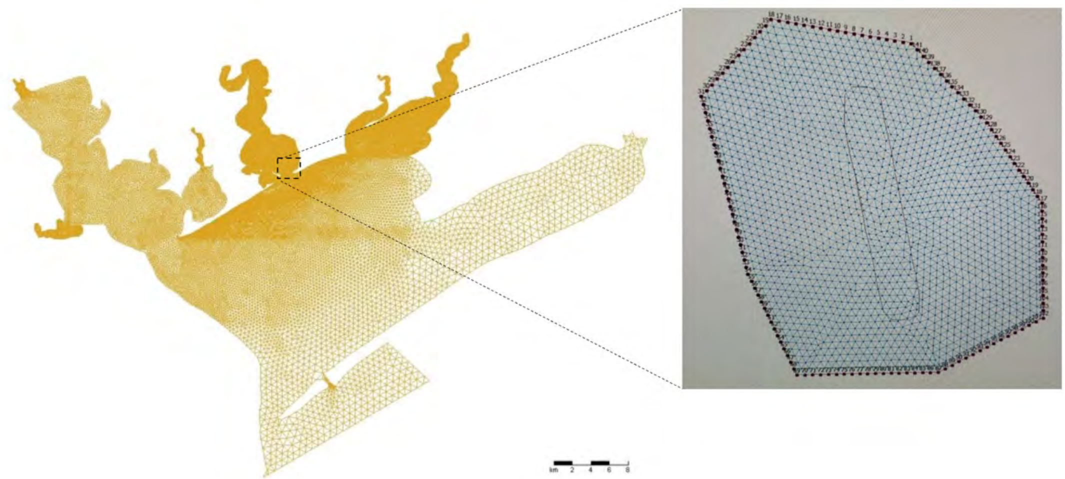
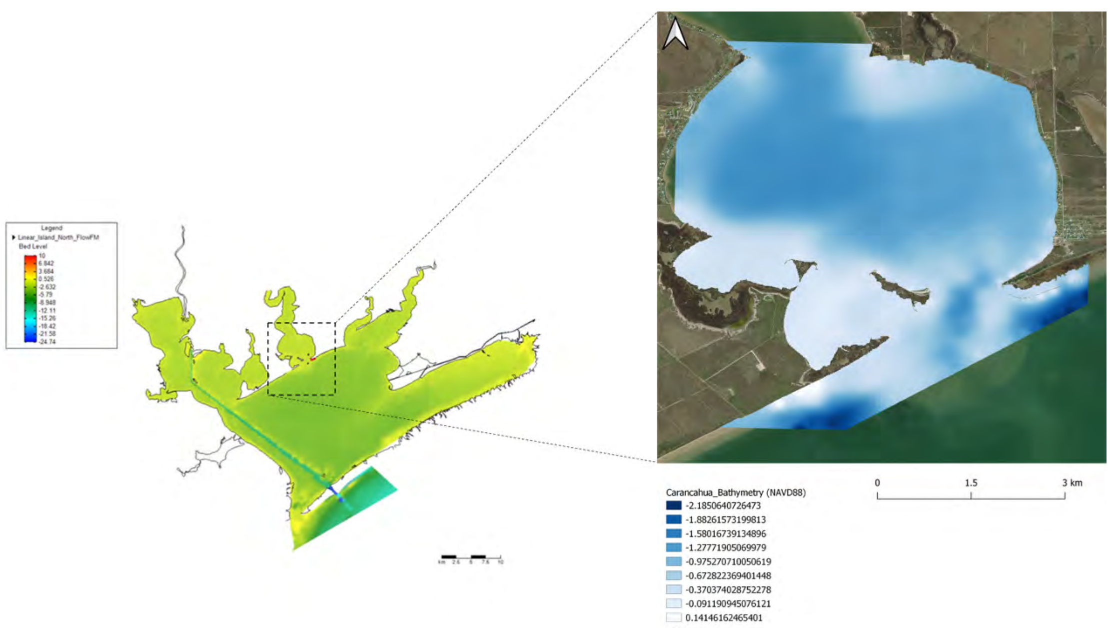


Fig. 2. Example of the bathymetry in the immediate study area of the Carancahua Bay inlet, and throughout the simulated basin.



Results

The specific numerical results and graphical products for the modeled alternatives can be found in Appendices 1-4. These materials can also be found in .pdf files, within the folder entitled “PDF”. There are also video products, but they can only be viewed by clicking on the.html files with the same names the folder entitled “HTML”, and then clicking play on the embedded videos.

We summarize the following key takeaways from these products with the following:

1. All structural alternatives do not measurably affect waves or flow velocities near existing soft sediment shorelines. There is no difference between any of the alternatives and a baseline ‘no-structure’ scenario, in terms of waves or flow velocities experienced on Redfish Island, Redfish Peninsula, in the Redfish Inlet, or on the far east marshes beyond Schicke Point. Moreover, all alternatives will likely have no appreciable effect on the structures currently being designed by GLO/FNI/TAMU on the western side of the Carancahua inlet. Similarly, these structures will likely not affect the Round North or Linear North alternatives. However, if these structures were designed to completely seal the mouth of Redfish Lake (which they are not), then they could potentially affect the Round Mouth and Linear Mouth alternatives by increasing the scouring velocities that they will encounter by ~1/3. In summary, there is no appreciable risk to existing soft shorelines, existing structures, or planned structures.

2. All alternatives provide some wave protection immediately next to the structure, but relatively minimal protection to Schicke Point. Structures placed inside the mouth of Carancahua Bay provide stronger wave protection to Schicke Point than those recessed inside it - yet these wave protection benefits will only occur during the most extreme wave events.

	Round Mouth	Linear Mouth	Round North	Linear North
Wave protection distance (rough avg, meters)	800	600	500	400
Wave protection benefit for Schicke Point	Minimal on south side	Very minimal on south side	Very minimal on north side	Very minimal on north side

Secondarily, the round structures provide greater wave protection than the linear structures. They produce a wider and longer distance wave shadow.

Overall, the Round Mouth option provides the greatest wave protection. Still in the big picture, the wave protection provided to Schicke Point is minimal because it is relatively far away.

3. Structures placed inside the mouth of Carancahua Bay reduce flow velocities more than those than those recessed inside of it, on average (measured at a distance of 10 meters from the sides of the structures). This fact is particularly true for (a) North-South moving velocities on the north and south sides of the structures, and (b) East-West moving velocities on the east and west sides.

   Although the structures recessed inside the bay increase E-W flow velocities, on average, their absolute increase is quite small (on the order of 0.01 meters per second) and likely inconsequential.

	Round Mouth	Linear Mouth	Round North	Linear North
N-S velocities				
N side	-0.09	-0.09	-0.06	-0.06
E side	-0.03	-0.07	-0.02	-0.05
S side	-0.07	-0.08	-0.07	-0.06
W side	-0.02	-0.06	-0.02	-0.04
E-W velocities				
N side	-0.04	0.00	0.01	0.01
E side	-0.06	-0.05	0.00	0.00
S side	-0.02	0.01	0.01	0.02
W side	-0.04	-0.06	0.02	-0.01

   Secondarily, the round structures generally reduce flow velocities more than the linear structures, on average. An exception to this fact occurs on the east and west sides of them, which is likely due their greater east-west shadow.

   The exact location of the structures and their distance from the primary bathymetric inlet channel may also play a part in any apparent differences. In particular, the structures inside the mouth are located on a relatively shallow area / sand bar, yet those inside the bay lie quite close to the deepest part of the inlet bathymetric channel.

   Overall, the Round Mouth option provides the greatest and most consistent flow velocity reductions, on average. The Linear Mouth option provides the second greatest reductions, on average. This result may be because the mouth is exposed to the greatest wave and flow energy to begin with.

4. Structures recessed inside Carancahua Bay produce less risk to altering the inlet exchange patterns than structures placed near its mouth. Sedimentary scouring and accretion patterns for the northern two alternatives will likely fall in line with the existing inlet flow dynamics. Moreover, there appears to be no remarkable change for these alternatives in the primary flow directions, during flood or ebb tides.

In contrast, structures placed near the mouth of Carancahua Bay will split the primary tidal flow path into two and force it to go around the structures. The eastern arm of flow appears faster between the structure location and the existing structure at Schicke Point, and it must traverse the existing ebb tidal delta / sand bar. While the overall volume of water exchange going through the western arm of flow is higher due to the deep bathymetry and wide cross-section of the existing channel pathway, it is the weaker arm in terms of velocity.

Souring and accretion patterns for the two alternatives in the mouth appear likely reinforce this imbalance, by depositing material inside the existing channel and eroding material from the existing sand bar. A bifurcated flow path could enhance erosion in undesirable locations, however a morphodynamic model would have to be run in order to understand the full magnitude of these potential consequences. We could produce such a model, but it would require a second contract and additional reimbursement.

Still, based on the available modeling results that we have, the overall velocity difference from the baseline “no-structure” scenario is less than 0.02 meters per second on the ebb tidal delta / sand bar / Schicke Point structure (and thus colored white on the videos). Thus, the risk of radically altering the morphology appears relatively low.

Discussion

If the sole goal is an island for bird habitat, then the Round North and Linear North may be best. The energy is relatively lower for structures recessed inside the bay and their structural integrity may hold together for a relatively longer time. The Linear North structure may work even better by rotating it on its center to orient its lengthwise elements in the NE-SW direction – then, it would be more parallel with, and a bit further away from the edge of the bathymetric channel. It would also be parallel with Schicke Point, and thus provide better protection from the northwesterly wave fetch.

If the goal is to reduce waves and velocities, then the Round Mouth and Linear Mouth may be best. The Round Mouth alternative appears best to reduce waves on Schicke Point and the best to reduce velocities within 10 meters of the placed structure. It likely will have lower scour potential and complex patterning than the Linear Mouth. The Linear Mouth is second in this respect. The Linear Mouth structure may work somewhat better by rotating it to align parallel along the channel dimension (to minimize effect on morphology in the channel bathymetry), or conversely perpendicular to it (to minimize the southwesterly wave fetch, while also not accumulating sediment into the channel bathymetry) – however to definitively identify the impact of various orientations, we would need to run a morphodynamic model. Both the Round Mouth and Linear Mouth appear to be sited at the most appropriate location on the ebb tidal delta / sand bar. However, they will split the flood and ebb tide pathway with potential long-term, albeit low risk, morphologic consequences to the existing ebb tidal delta / sand bar.

Appendices 1-4: Numerical Results and Graphical Products

(See .html files in HTML folder for embedded videos – not shown here)

FNI Linear Island Mouth

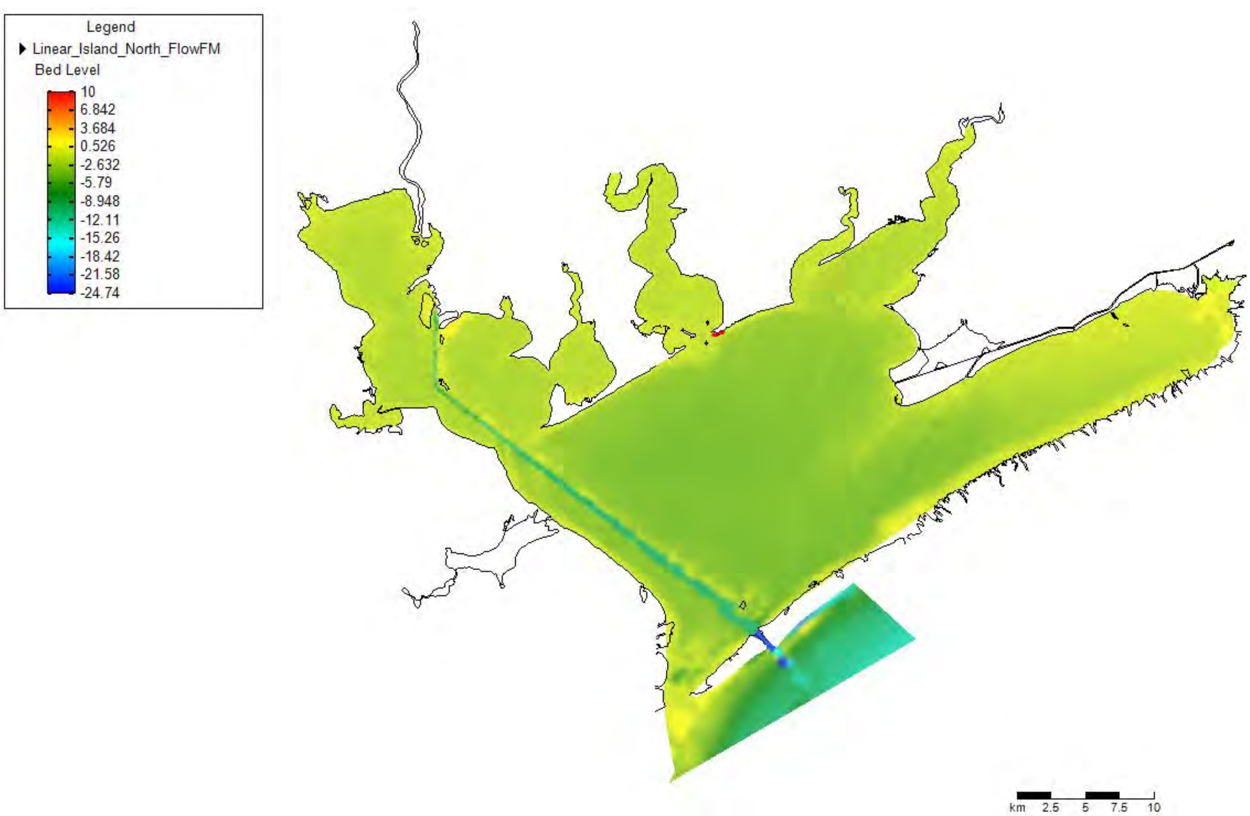
1/27/2022

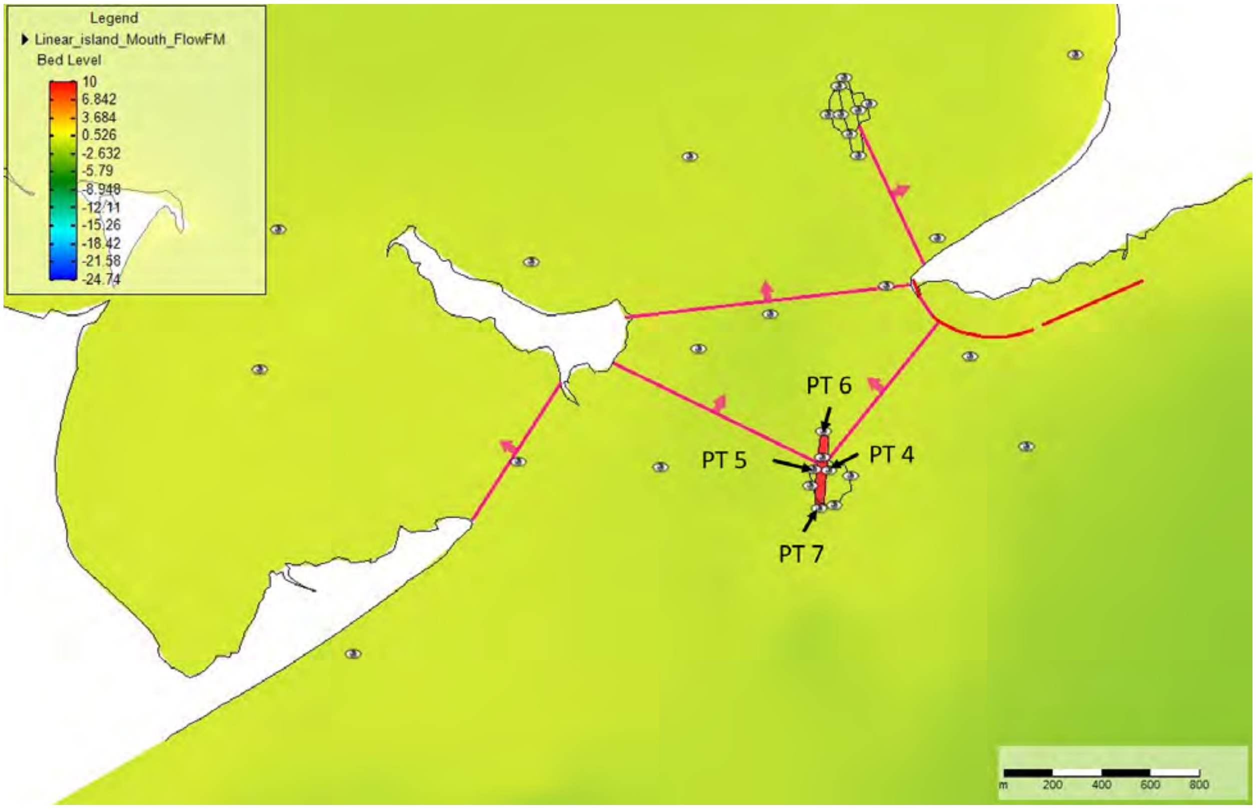
Model Description

Two model runs were conducted using a large scale flexible mesh grid that extended into the Gulf of Mexico. One run simulated a baseline condition that we call "base" and the second that simulated the effect of a long barrier placed along the West Matagorda Bay shoreline that we call "barrier".

Both models were parameterized using GLO/TAMU and NOAA data and covered January to July 2020 dates. Both included wind, waves, depth averaged flow direction and velocity, and salinity. Both used the same forcing parameters with the only difference being the tested structure. The bathymetry was modified to create a "barrier" structure that was 10 m in height, thus overtopping of the structure was not allowed to occur.

Four locations were selected for comparison: observation point 4 (just east of the structure), observation point 5 (just west of the structure), observation point 6 (just north of the structure), and observation point 7 (just south of the structure).



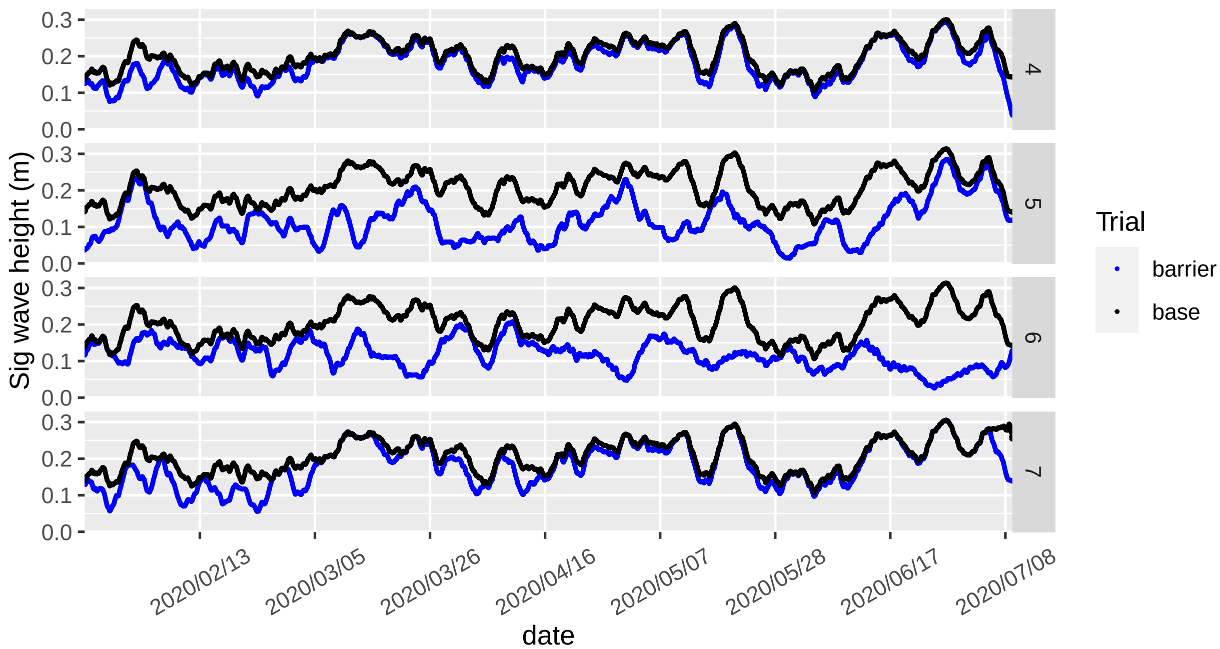


Wave Reduction

The significant wave heights for each observation point are shown in table below.

	baseline Sig wave height	FNI_barrier Sig wave height
Obvs_pt_4	0.20	0.18
Obvs_pt_5	0.21	0.12
Obvs_pt_6	0.20	0.12
Obvs_pt_7	0.20	0.18

The significant wave heights over time are shown below (blue represents the barrier and black the baseline).

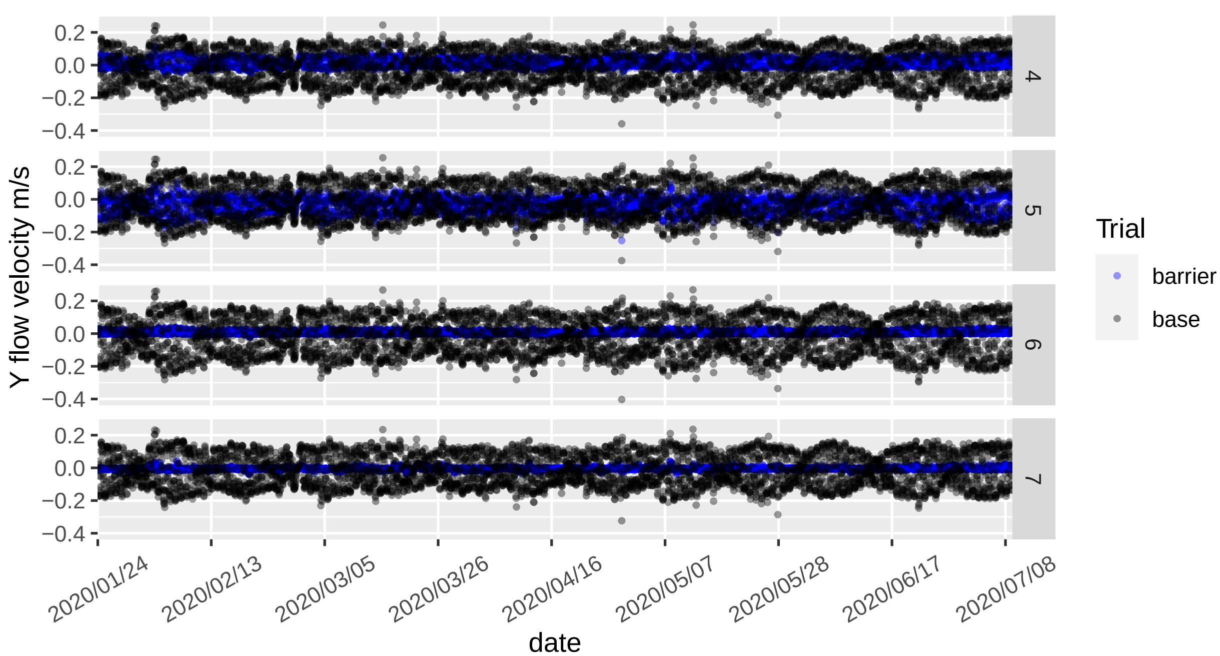


Flow Velocity and Direction

The mean flow velocities in the y direction (north-south) for each observation point are shown below.

	baseline (m/s) Y	FNI_barrier (m/s) Y
Obvs_pt_4	0.09	0.02
Obvs_pt_5	0.10	0.04
Obvs_pt_6	0.10	0.01
Obvs_pt_7	0.09	0.01

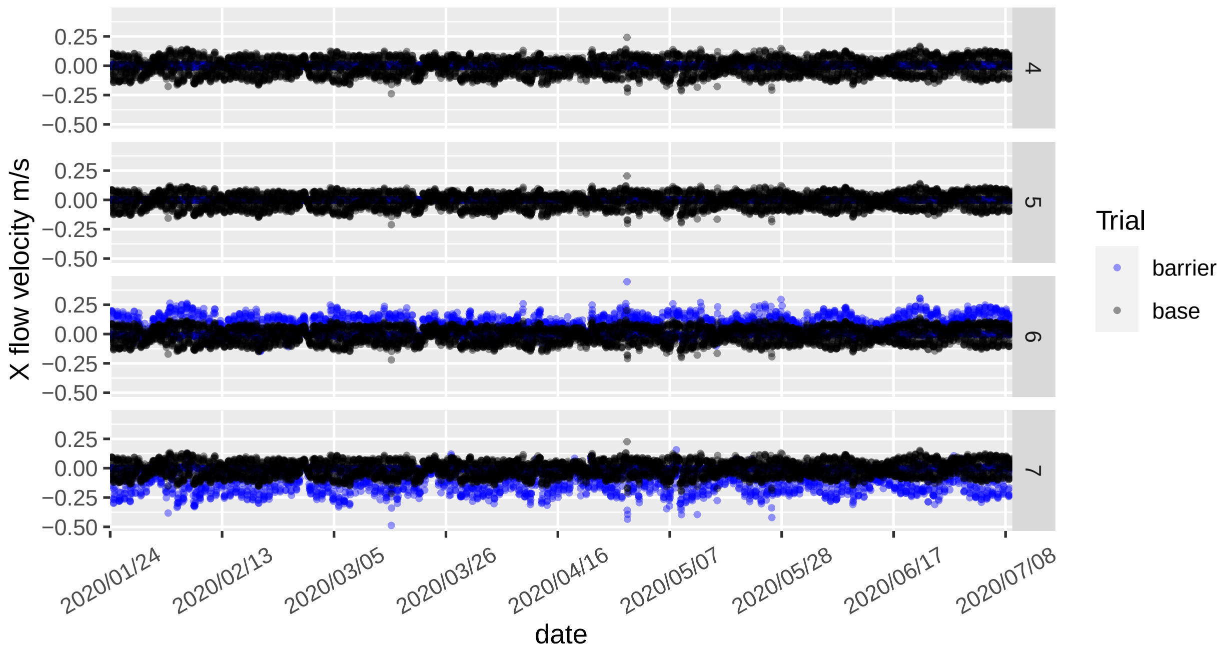
The flow velocities over time in the y direction (north-south) are shown below.



The mean flow velocities in the x direction (east-west) for each observation point are shown below.

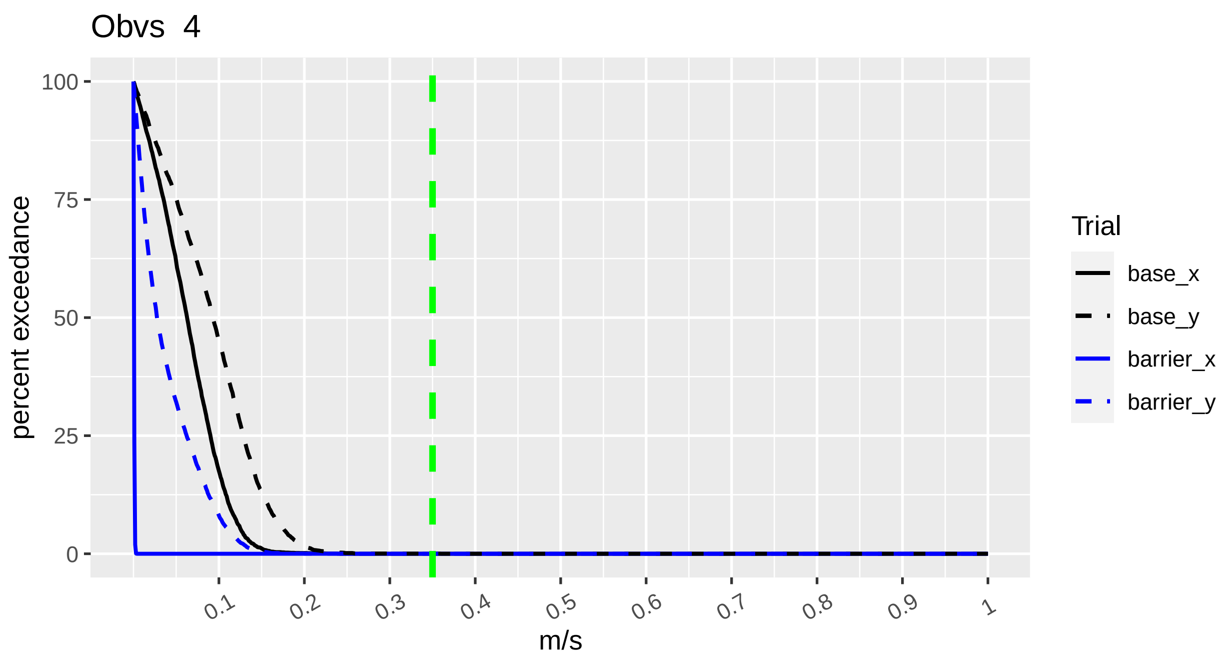
	baseline (m/s) X	FNI_barrier (m/s) X
Obvs_pt_4	0.06	0.01
Obvs_pt_5	0.06	0.00
Obvs_pt_6	0.06	0.06
Obvs_pt_7	0.06	0.07

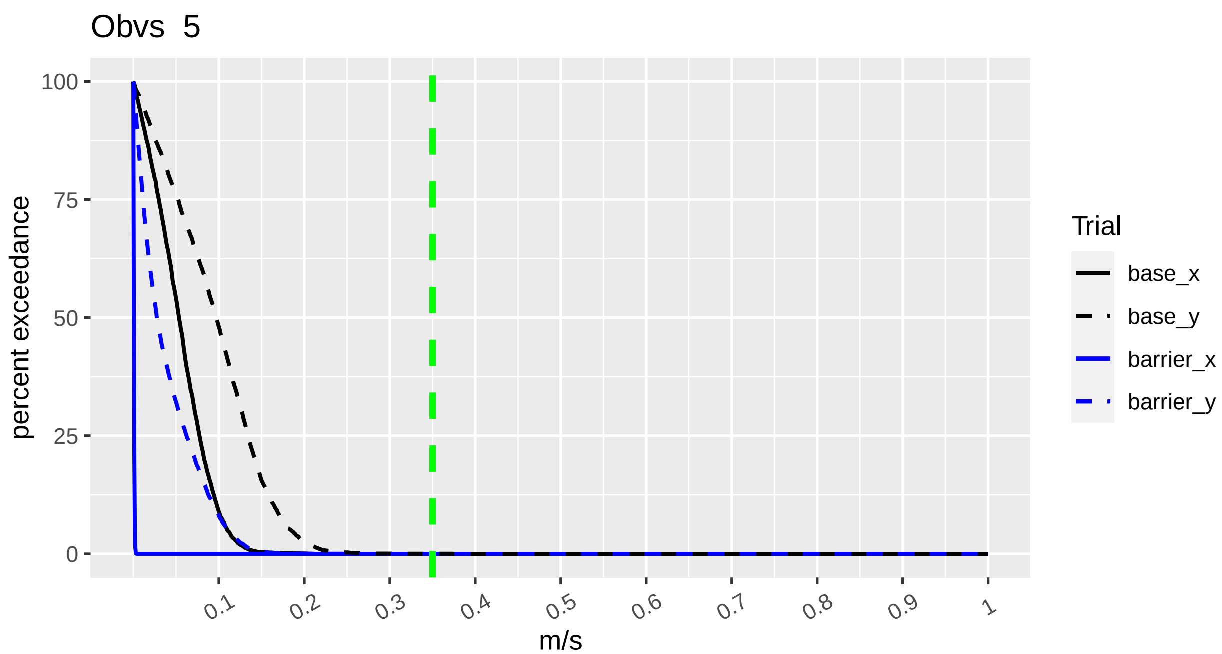
The flow velocities over time in the x direction (east-west) are shown below.

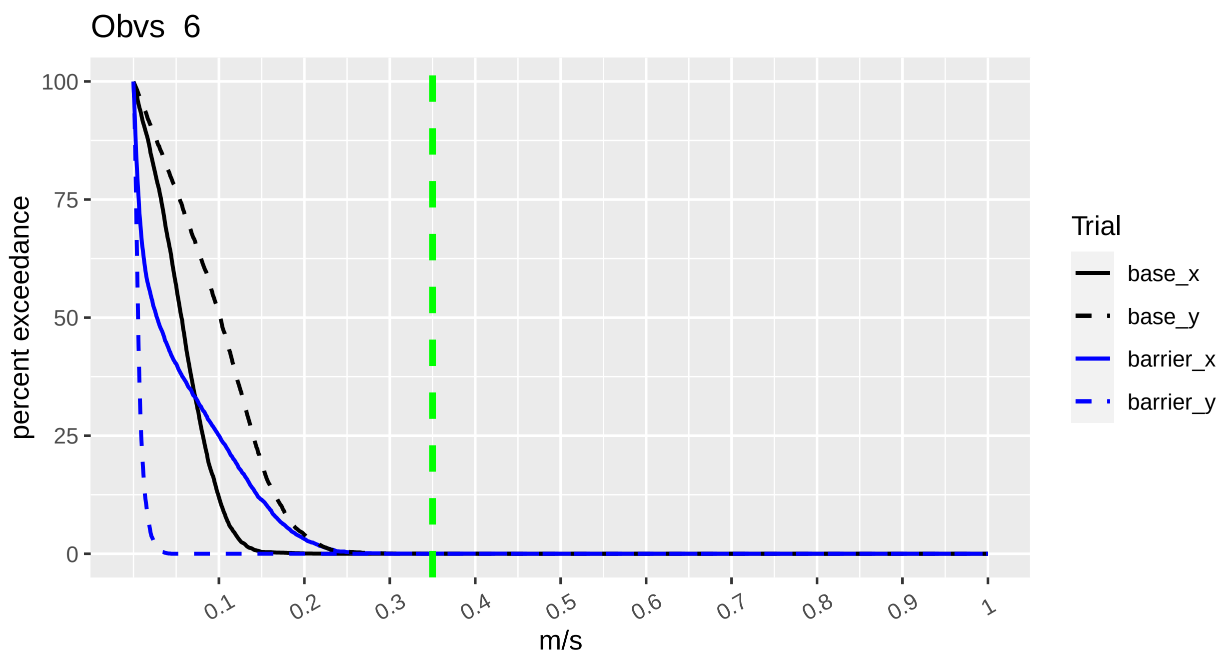


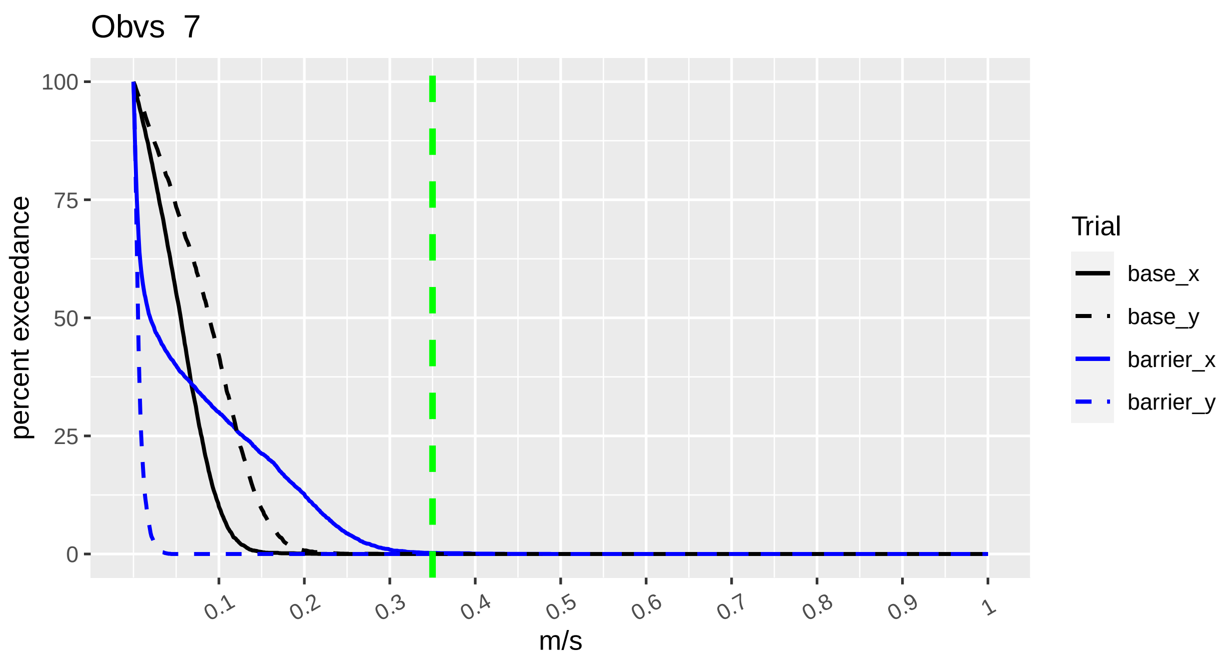
Flow Exceedance

Velocity exceedance plots were also generated and show the percent of the time that the depth-averaged flow exceeds a given velocity in the north-south direction. Previous work by GLO/TAMU has established 0.35m/s as the threshold for erosion of unconsolidated material along the study area shorelines (dashed green line).


Obvs 4
100
75
50
25
0
percent exceedance
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
m/s
Trial
base_x
base_y
barrier_x
barrier_y


Obvs 5
100
75
50
25
0
percent exceedance
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
m/s
Trial
base_x
base_y
barrier_x
barrier_y



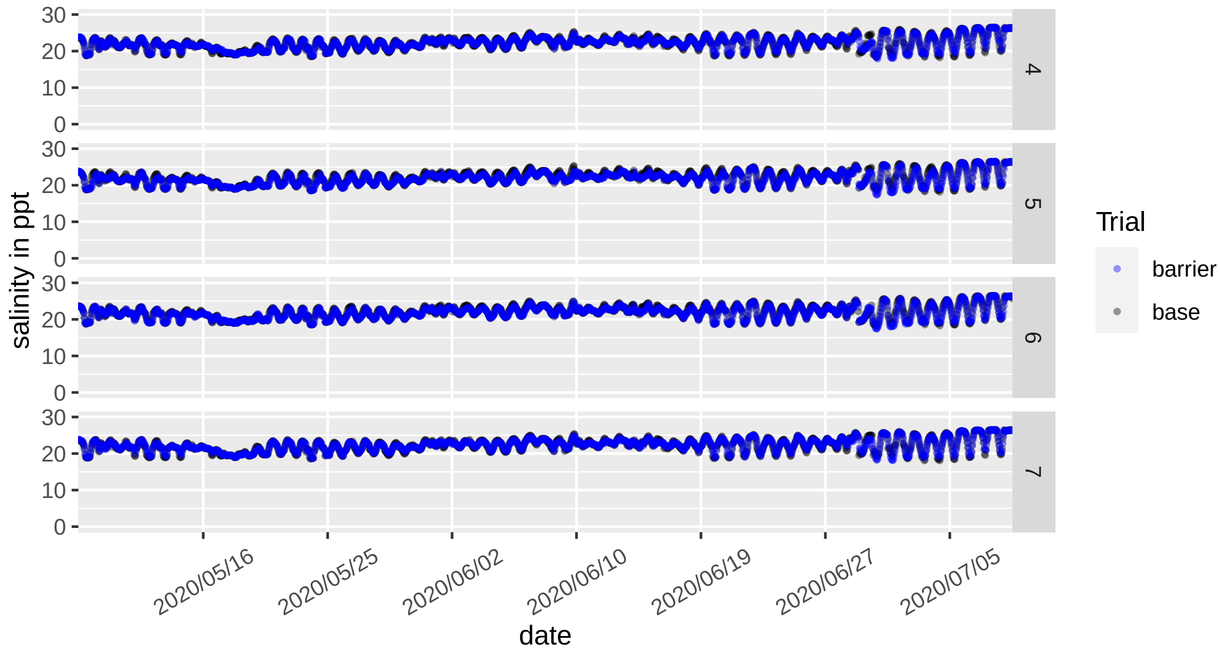


Salinity

The mean salinities for each observation point and trial are shown in the table below. Due to the initilization time of the model only the last 1500 records are analysed.

	baseline ppt	barrier ppt
Obvs_pt_4	22.17	22.15
Obvs_pt_5	22.15	21.81
Obvs_pt_6	22.05	21.80
Obvs_pt_7	22.28	22.31

The last 1500 salinity samples are graphed below.



Summary

This structure reduced the significant wave height in all directions, particularly on the western and northern sides of the structure by almost 1/2. It only slightly reduced waves on south and east. The wave protection afforded by the structure generally extended ~600 m away from it, on average, and it occasionally provided protection to Schicke Point, particularly during SW wind events which have the largest fetch length and wave size.

The structure greatly reduced the N-S direction average water flow velocities at all observation points (on the cardinal directions N, S, E, W). For example, the average velocity dropped an entire order of magnitude, from 0.10 to 0.01 meters per second. This effect was similar on all sides, except for the west where it only dropped by ~1/2. The structure also greatly reduced the E-W direction velocities (on the east and west sides), for example going from 0.06 to 0.00 on the western side.

There should be some concern that the predominant pattern of inlet-bay exchange could re-route itself to flow between the structure and the existing Schicke Point structure. Because the new structure reduces the velocities on the northwestern side, sediment could accumulate into the bathymetric inlet channel that enters into the mouth of Carancahua. In addition, the increased scouring of sediment on the northeast side would begin to reinforce this pattern. This would likely be to the benefit of Redfish Lake side of the inlet but to the detriment of Schicke Point, in terms of net accretion/erosion balance.

However, a change in flow routing appears more strongly to occur for incoming tidal exchange (flood tides) than outgoing exchange (ebb tides). During the most extreme outgoing tidal events, the scouring pattern is slightly different than the average and appears likely to keep the main channel open. Thus, it is possible that a structure in this location will only partially re-route flow, and create more of a bifurcated flow pattern that goes around both sides of the island.

FNI Round Island Mouth

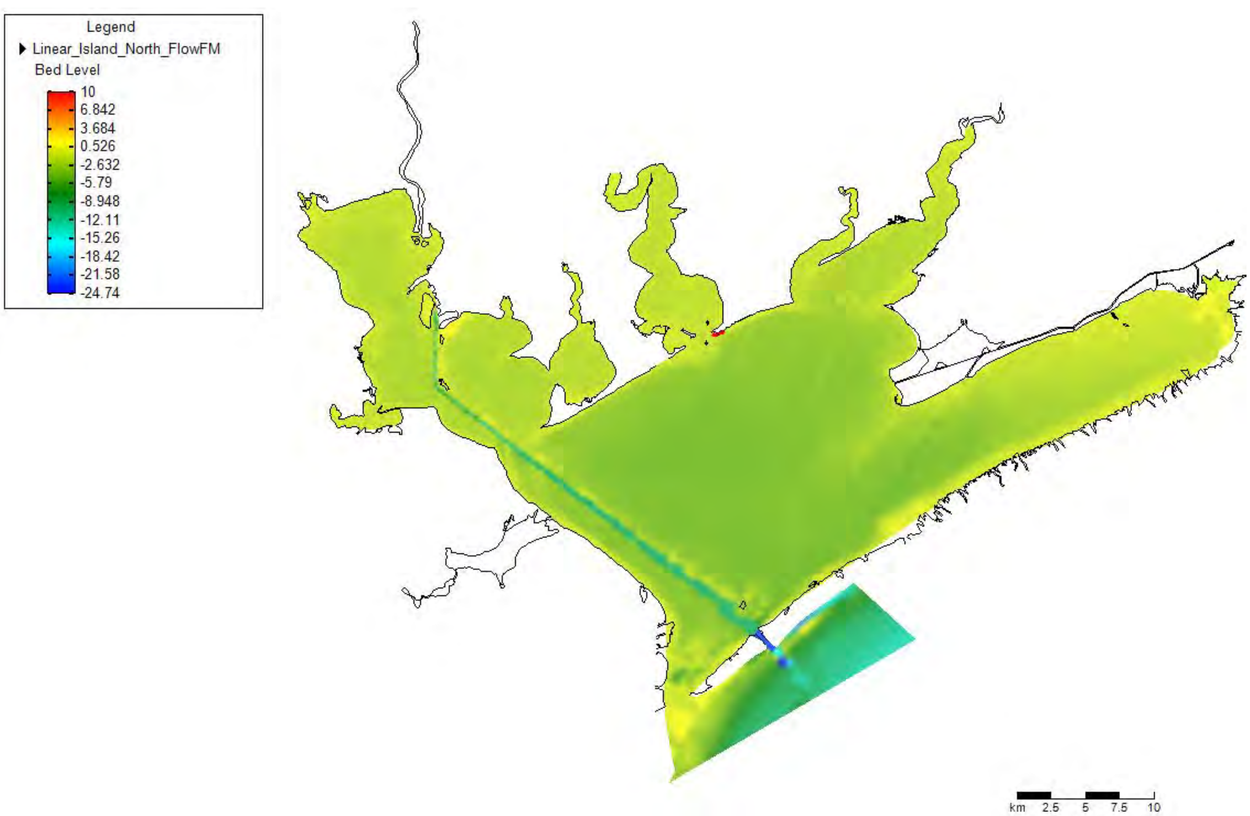
1/24/2022

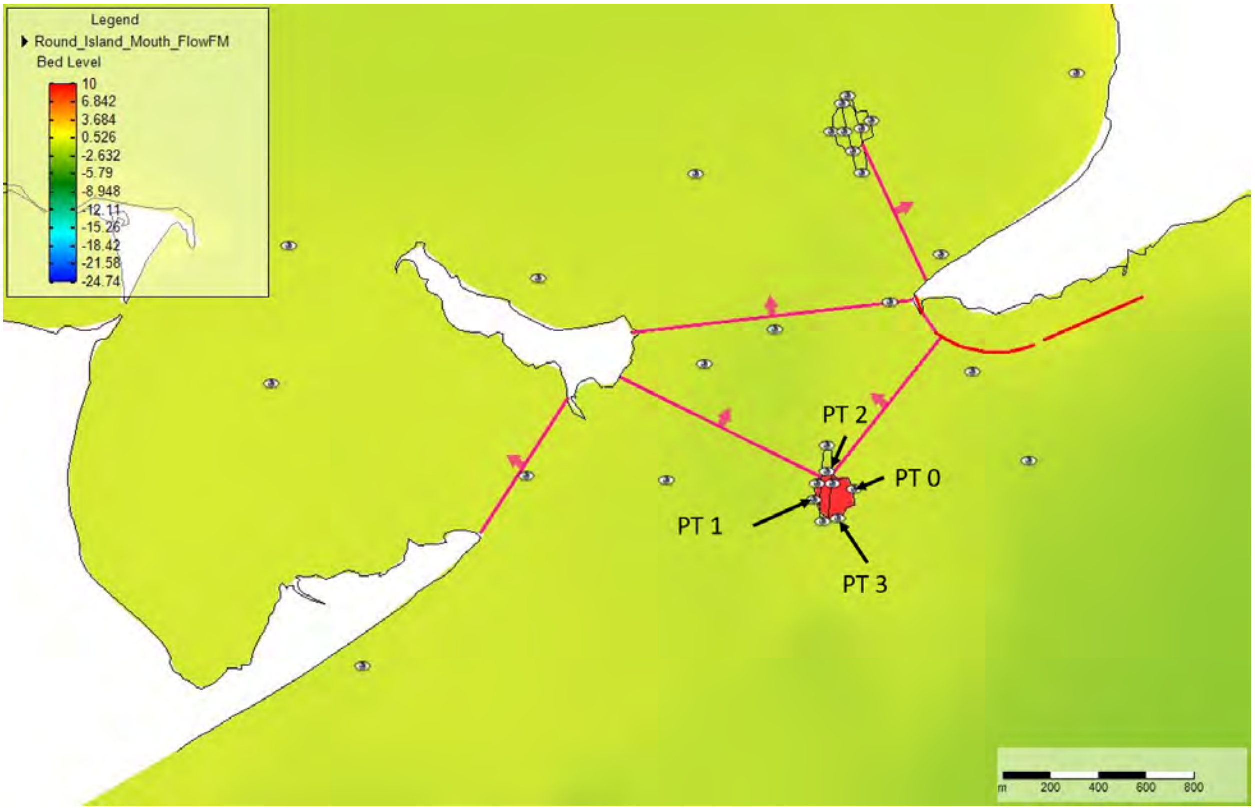
Model Description

Two model runs were conducted using a large scale flexible mesh grid that extended into the Gulf of Mexico. One run simulated a baseline condition that we call “base” and the second that simulated the effect of a long barrier placed along the West Matagorda Bay shoreline that we call “barrier”.

Both models were parameterized using GLO/TAMU and NOAA data and covered January to July 2020 dates. Both included wind, waves, depth averaged flow direction and velocity, and salinity. Both used the same forcing parameters with the only difference being the tested structure. The bathymetry was modified to create a “barrier” structure that was 10 m in height, thus overtopping of the structure was not allowed to occur.

Four locations were selected for comparison: observation point 0 (just east of the structure), observation point 1 (just west of the structure), observation point 2 (just north of the structure), and observation point 3 (just south of the structure).



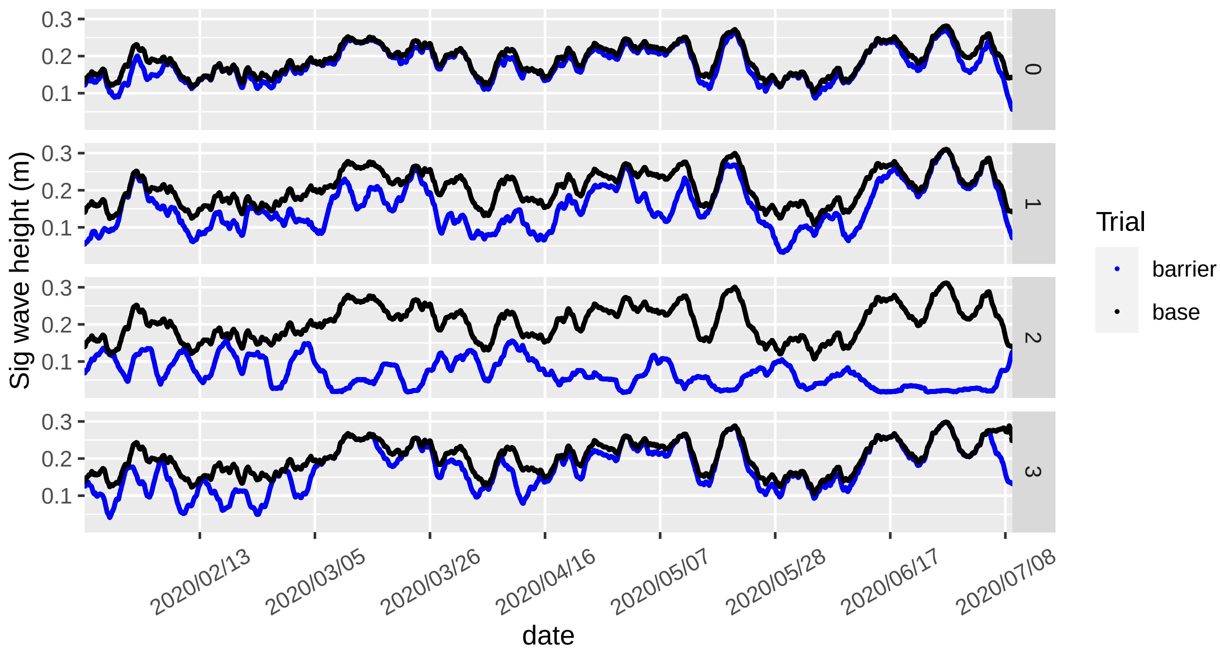


Wave Reduction

The significant wave heights for each observation point are shown in table below.

	baseline Sig wave height	FNI_barrier Sig wave height
Obvs_pt_0	0.19	0.18
Obvs_pt_1	0.21	0.16
Obvs_pt_2	0.21	0.07
Obvs_pt_3	0.20	0.17

The significant wave heights over time are shown below (blue represents the barrier and black the baseline).

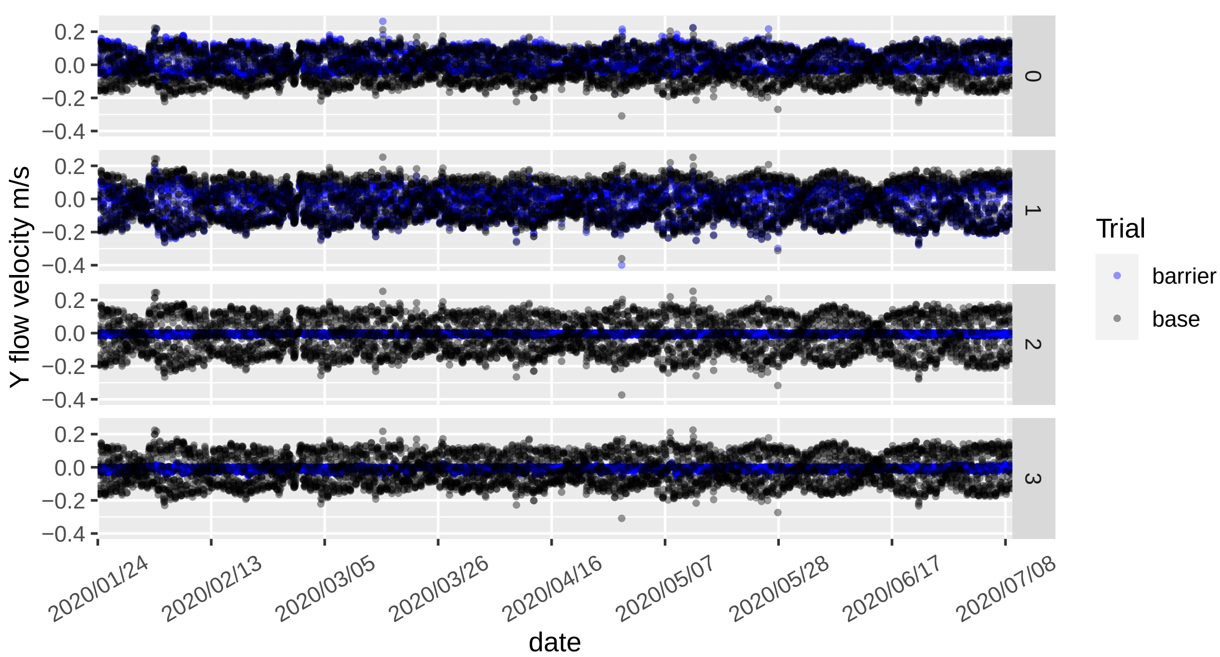


Flow Velocity and Direction

The mean flow velocities in the y direction (north-south) for each observation point are shown below.

	baseline (m/s) Y	FNI_barrier (m/s) Y
Obvs_pt_0	0.08	0.05
Obvs_pt_1	0.09	0.07
Obvs_pt_2	0.09	0.00
Obvs_pt_3	0.08	0.01

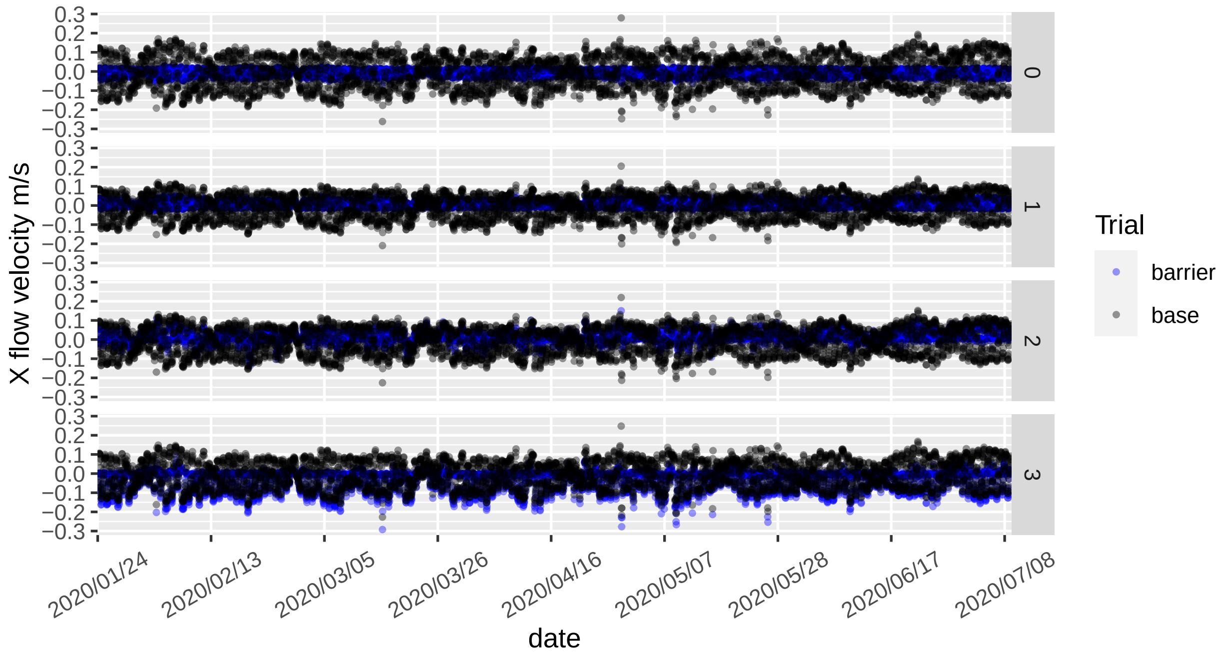
The flow velocities over time in the y direction (north-south) are shown below.



The mean flow velocities in the x direction (east-west) for each observation point are shown below.

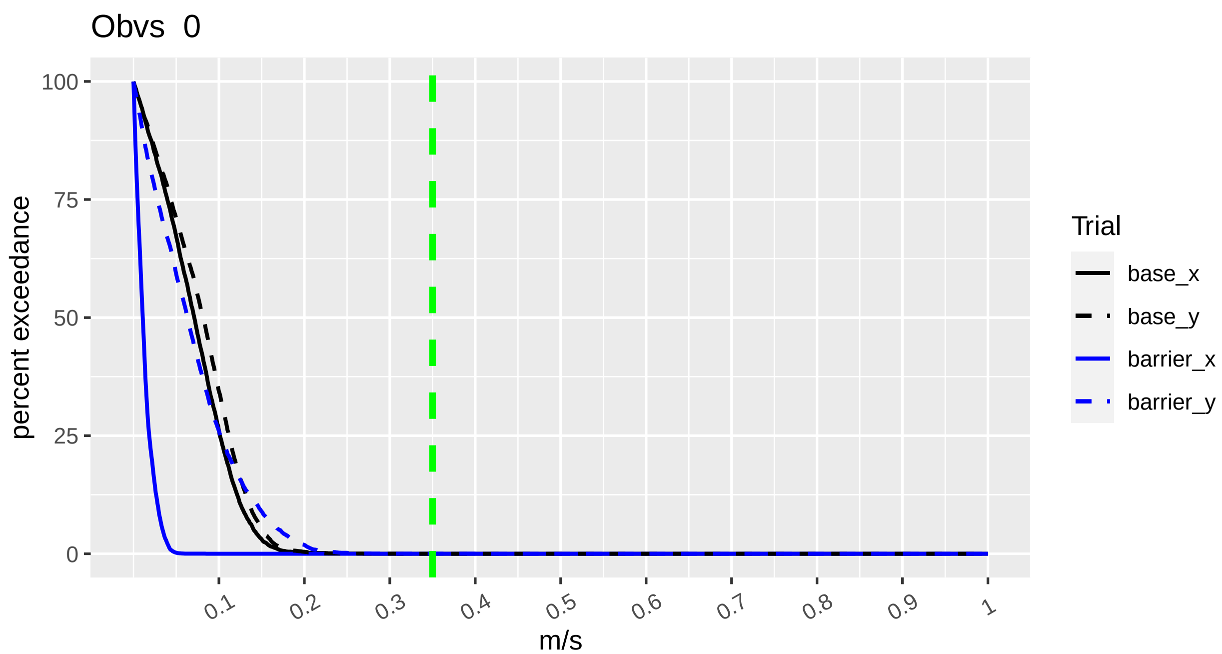
	baseline (m/s) X	FNI_barrier (m/s) X
Obvs_pt_0	0.07	0.01
Obvs_pt_1	0.05	0.01
Obvs_pt_2	0.06	0.02
Obvs_pt_3	0.06	0.04

The flow velocities over time in the x direction (east-west) are shown below.

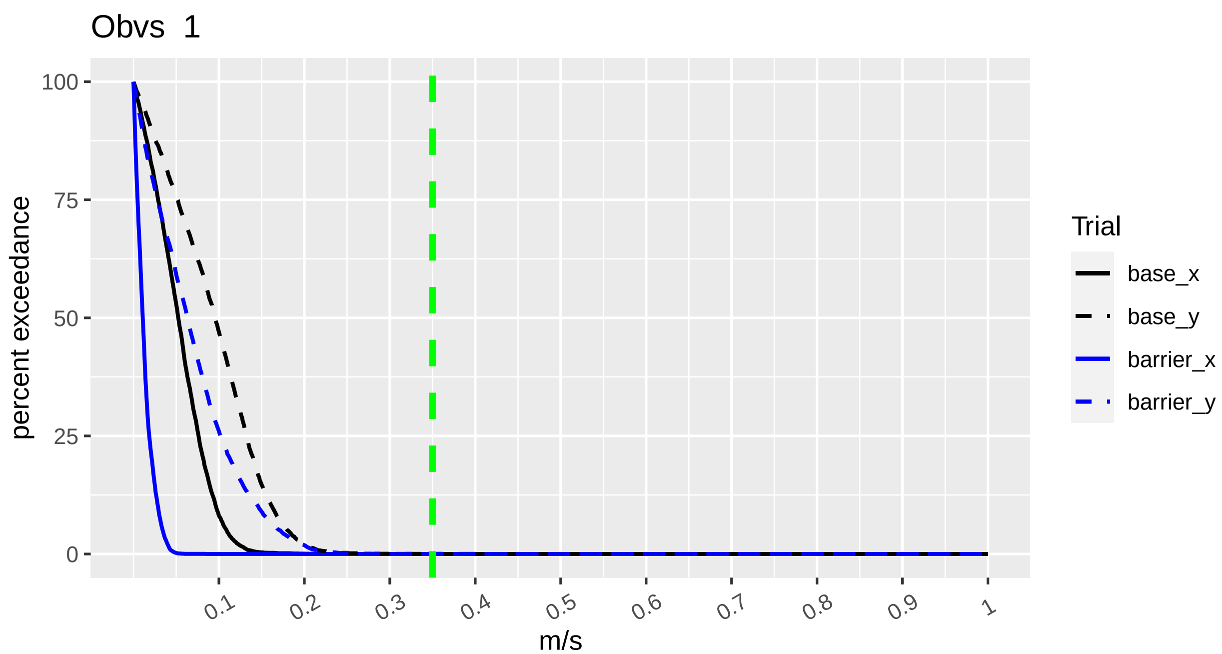


Flow Exceedance

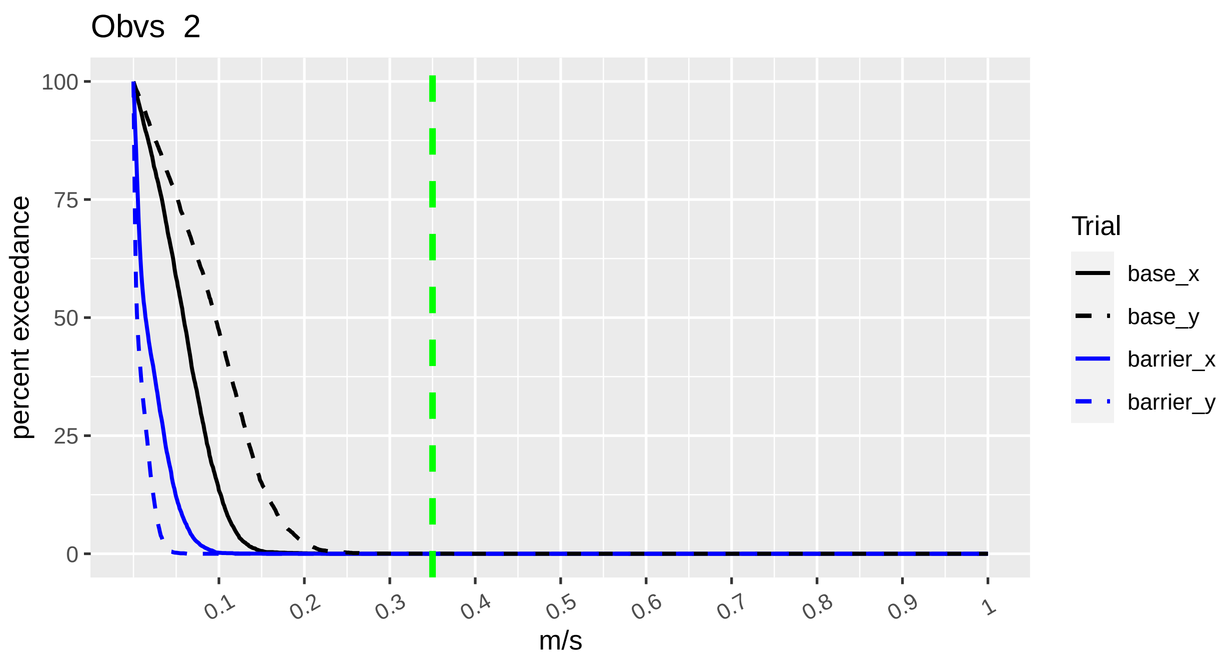
Velocity exceedance plots were also generated and show the percent of the time that the depth-averaged flow exceeds a given velocity in the north-south direction. Previous work by GLO/TAMU has established 0.35m/s as the threshold for erosion of unconsolidated material along the study area shorelines (dashed green line).

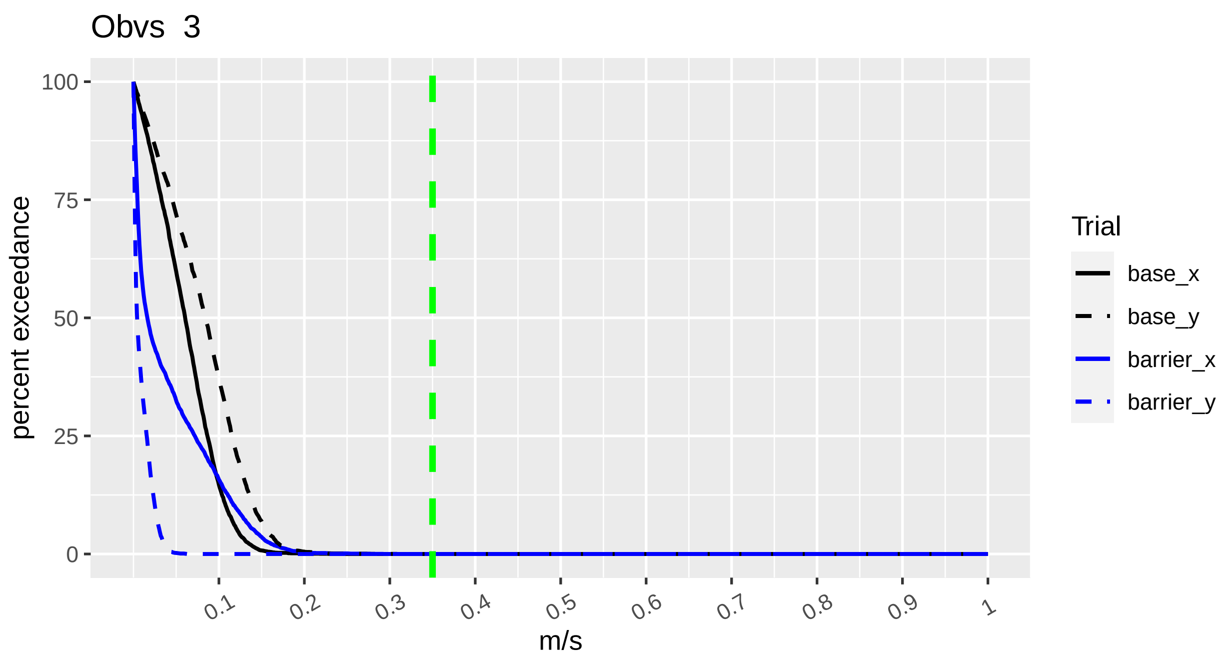


Obvs 0
percent exceedance
100
75
50
25
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
m/s
Trial
base_x
base_y
barrier_x
barrier_y



Obvs 1
percent exceedance
100
75
50
25
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
m/s
Trial
base_x
base_y
barrier_x
barrier_y



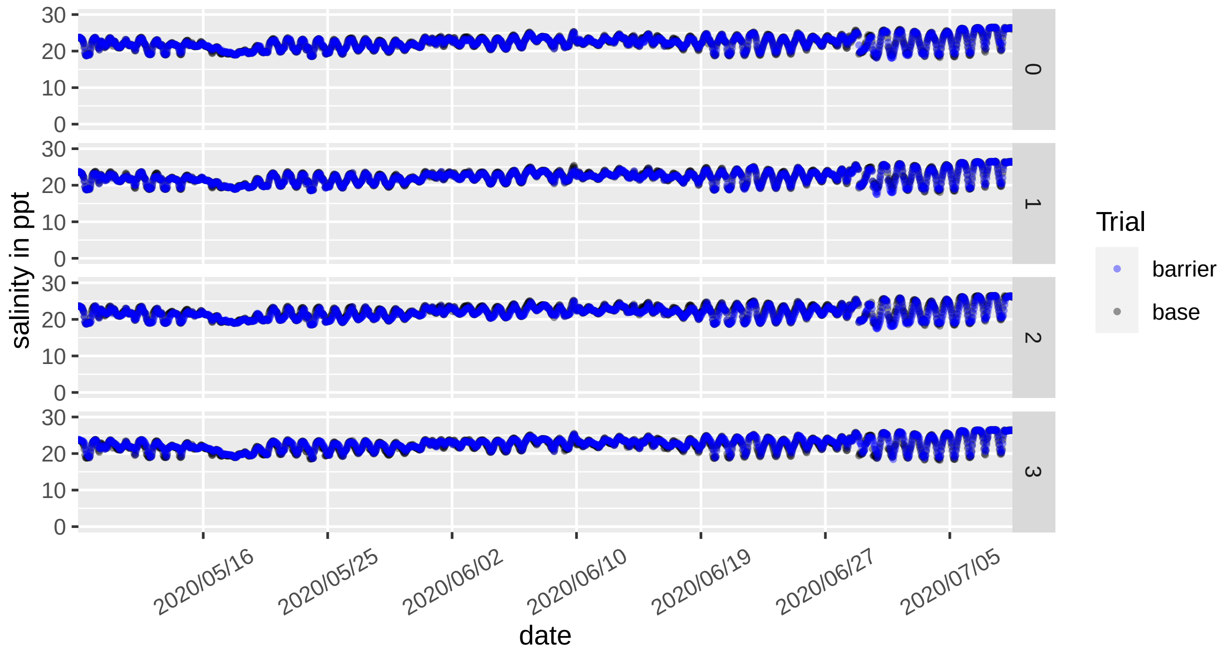


Salinity

The mean salinities for each observation point and trial are shown in the table below. Due to the initilization time of the model only the last 1500 records are analysed.

	baseline ppt	barrier ppt
Obvs_pt_0	22.20	22.20
Obvs_pt_1	22.20	22.09
Obvs_pt_2	22.12	21.77
Obvs_pt_3	22.28	22.52

The last 1500 salinity samples are graphed below.



Summary

This structure reduced the significant wave height in all directions, particularly on the northern side of the structure by almost 2/3. It only slightly reduced waves in the other directions. The wave protection afforded by the structure generally extended ~800 m away from it, on average, and it occasionally provided protection to Schicke Point, particularly during SW wind events which have the largest fetch length and wave size.

The structure greatly reduced the N-S direction average water flow velocities on its northern and southern sides, but slightly less so on its eastern and western sides. For example, the average velocity dropped on the northern side an entire order of magnitude, from 0.10 to 0.01 meters per second. In particular, it only dropped ~1/5 on its western side. The structure also greatly reduced the E-W direction velocities on all sides.

There should be some concern that the predominant pattern of inlet-bay exchange could re-route itself to flow between the structure and the existing Schicke Point structure. Because the new structure reduces the velocities on the northwestern side, sediment could accumulate into the bathymetric inlet channel that enters into the mouth of Carancahua. In addition, the increased scouring of sediment on the northeast side would begin to reinforce this pattern. This would likely be to the benefit of Redfish Lake side of the inlet but to the detriment of Schicke Point, in terms of net accretion/erosion balance.

However, a change in flow routing appears more strongly to occur for incoming tidal exchange (flood tides) than outgoing exchange (ebb tides). During the most extreme outgoing tidal events, the scouring pattern is slightly different than the average and appears likely to keep the main channel open. Thus, it is possible that a structure in this location will only partially re-route flow, and create more of a bifurcated flow pattern that goes around both sides of the island.

FNI Linear Island North

1/27/2022

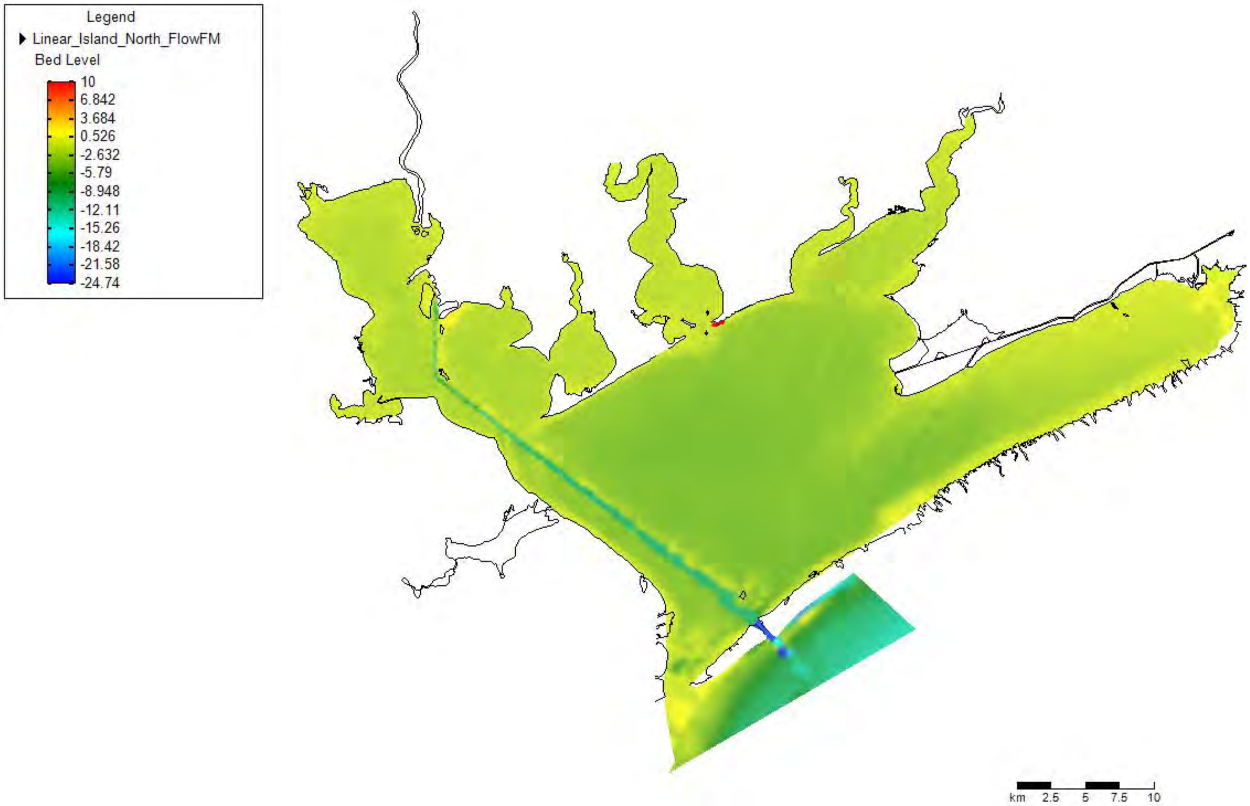
Model Description

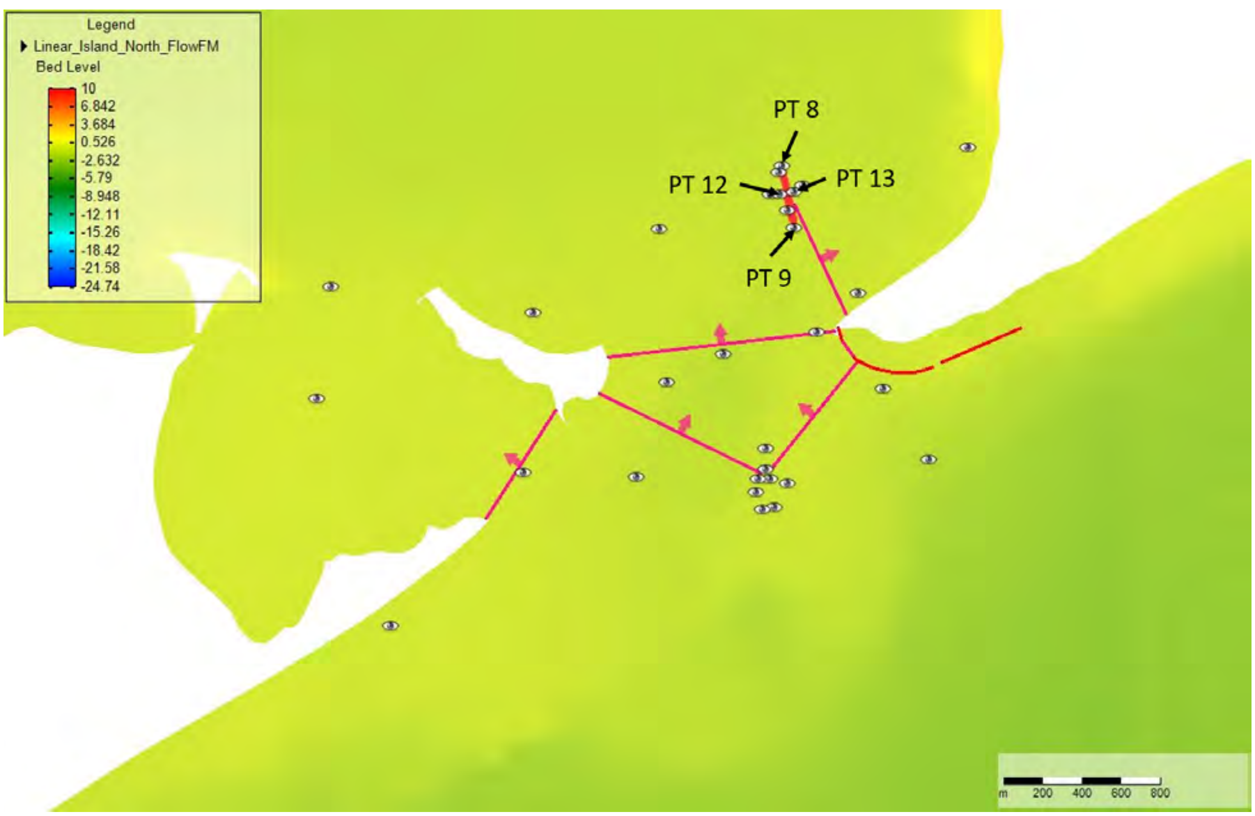
Two model runs were conducted using a large scale flexible mesh grid that extended into the Gulf of Mexico. One run simulated a baseline condition that we call “base” and the second that simulated the effect of a long barrier placed along the West Matagorda Bay shoreline that we call “barrier”.

Both models were parameterized using GLO/TAMU and NOAA data and covered January to July 2020 dates. Both included wind, waves, depth averaged flow direction and velocity, and salinity. Both used the same forcing parameters with the only difference being the tested structure. The bathymetry was modified to create a “barrier” structure that was 10 m in height, thus overtopping of the structure was not allowed to occur.

Four locations were selected for comparison: observation point 8 (just north of the structure), observation point 9 (just south of the structure), observation point 12 (just west of the structure), and observation point 13 (just east of the structure).

Both models were parameterized using TAMU and NOAA data and covered January to July 2020 dates. Both included wind, waves, depth averaged flow direction and velocity, and salinity. Both used the same forcing parameters with the only difference being the tested structure. The DELFT3D thin dam tool was used to create the “barrier” structure, as shown in the figure below. The barrier had an infinite height, thus overtopping was not considered in this model.


Legend
Linear_Island_North_FlowFM
Bed Level
10
6.842
3.684
0.526
-2.632
-5.79
-8.948
-12.11
-15.26
-18.42
-21.58
-24.74
km 2.5 5 7.5 10

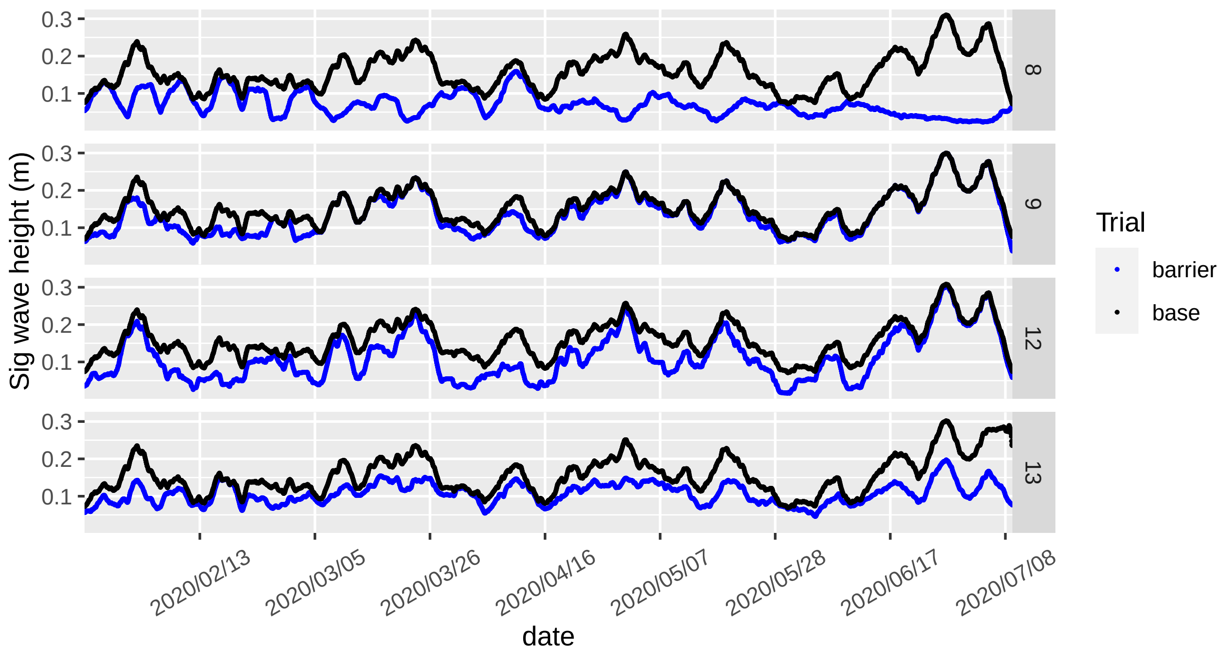

Legend
Linear_Island_North_FlowFM
Bed Level
10
6.842
3.684
0.526
-2.632
-5.79
-8.948
-12.11
-15.26
-18.42
-21.58
-24.74
PT 8
PT 12
PT 13
PT 9
m 200 400 600 800

Wave Reduction

The significant wave heights for each observation point are shown in table below.

	baseline Sig wave height	FNI_barrier Sig wave height
Obvs_pt_8	0.16	0.07
Obvs_pt_9	0.15	0.14
Obvs_pt_12	0.16	0.11
Obvs_pt_13	0.15	0.11

The significant wave heights over time are shown below (blue represents the barrier and black the baseline).

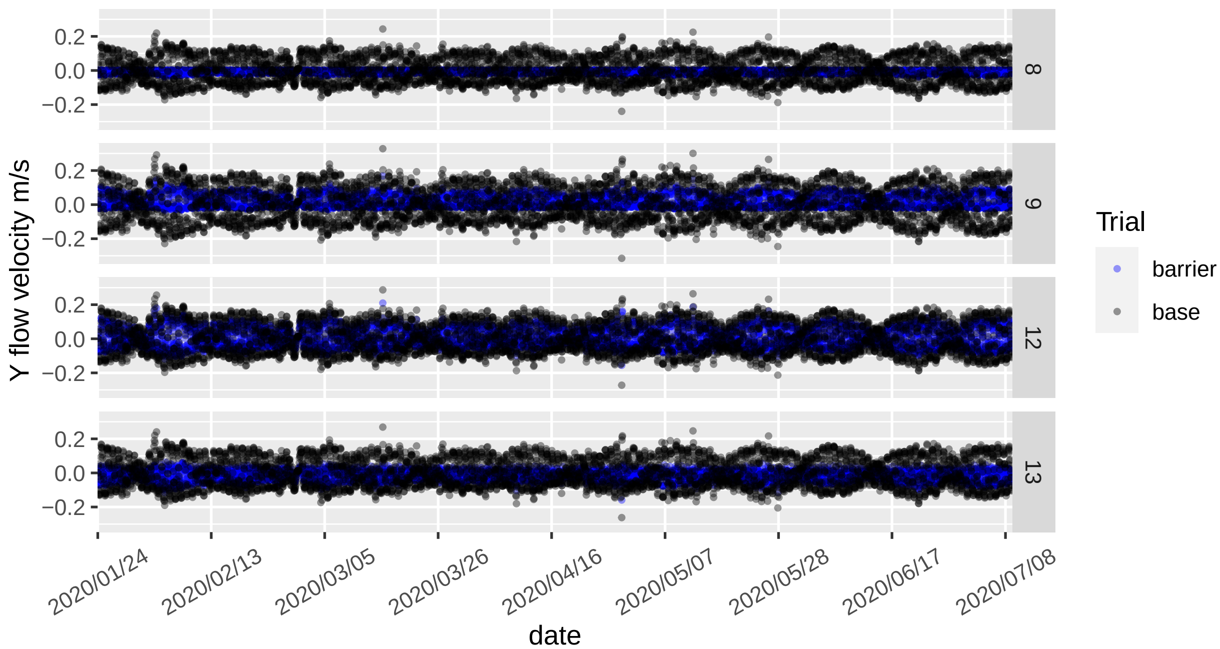


Flow Velocity and Direction

The mean flow velocities in the y direction (north-south) for each observation point are shown below.

	baseline (m/s) Y	FNI_barrier (m/s) Y
Obvs_pt_8	0.07	0.01
Obvs_pt_9	0.09	0.03
Obvs_pt_12	0.08	0.04
Obvs_pt_13	0.07	0.02

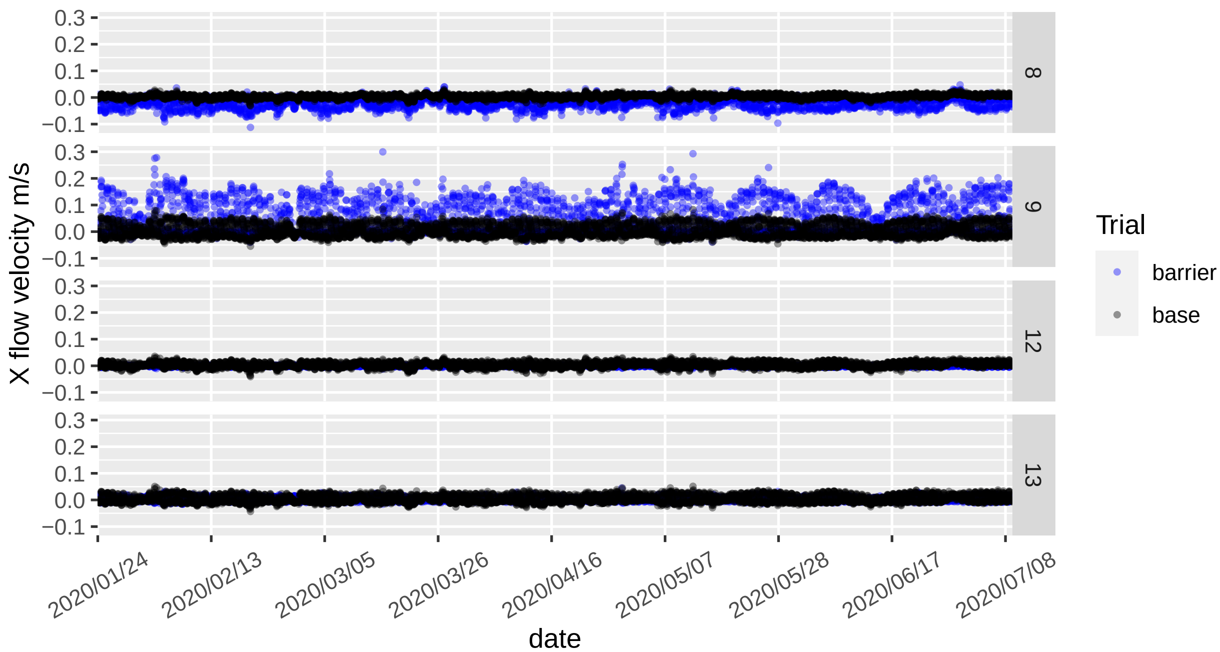
The flow velocities over time in the y direction (north-south) are shown below.



The mean flow velocities in the x direction (east-west) for each observation point are shown below.

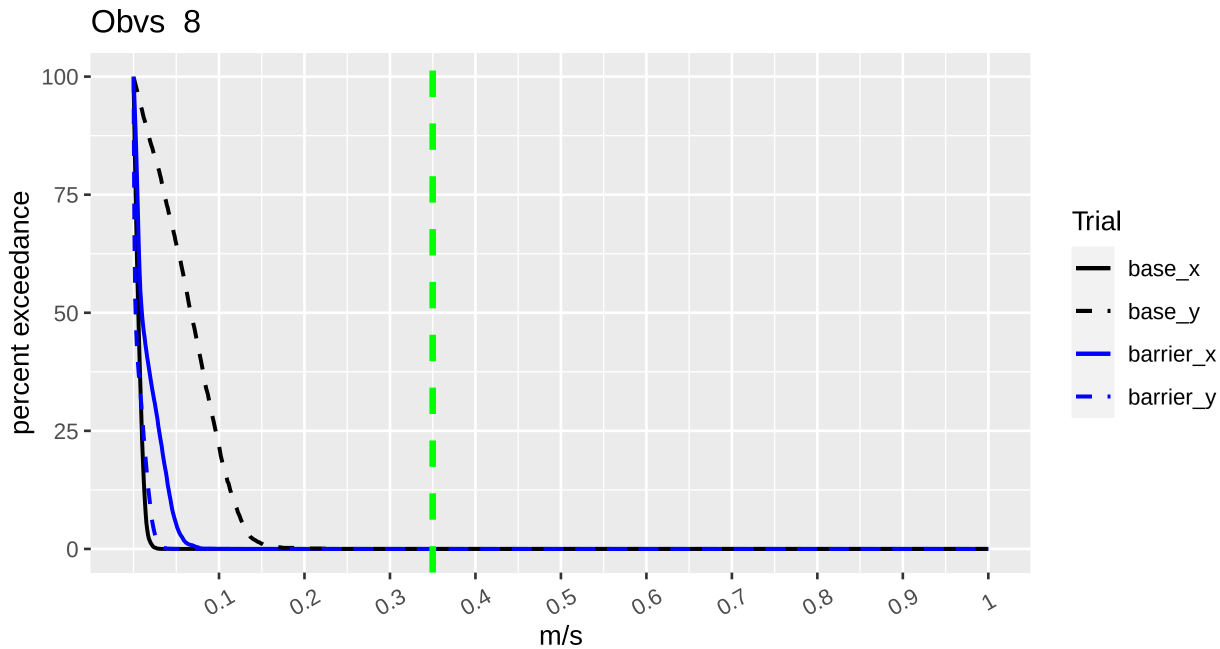
	baseline (m/s) X	FNI_barrier (m/s) X
Obvs_pt_8	0.01	0.02
Obvs_pt_9	0.02	0.04
Obvs_pt_12	0.01	0.00
Obvs_pt_13	0.01	0.01

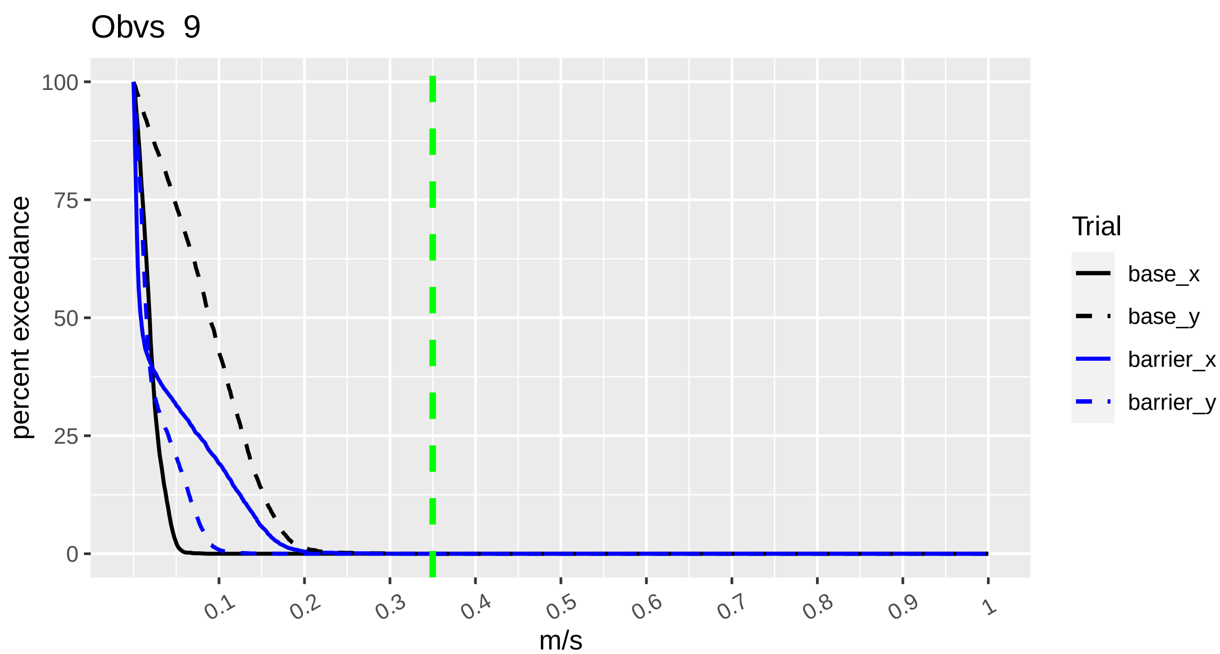
The flow velocities over time in the x direction (east-west) are shown below.

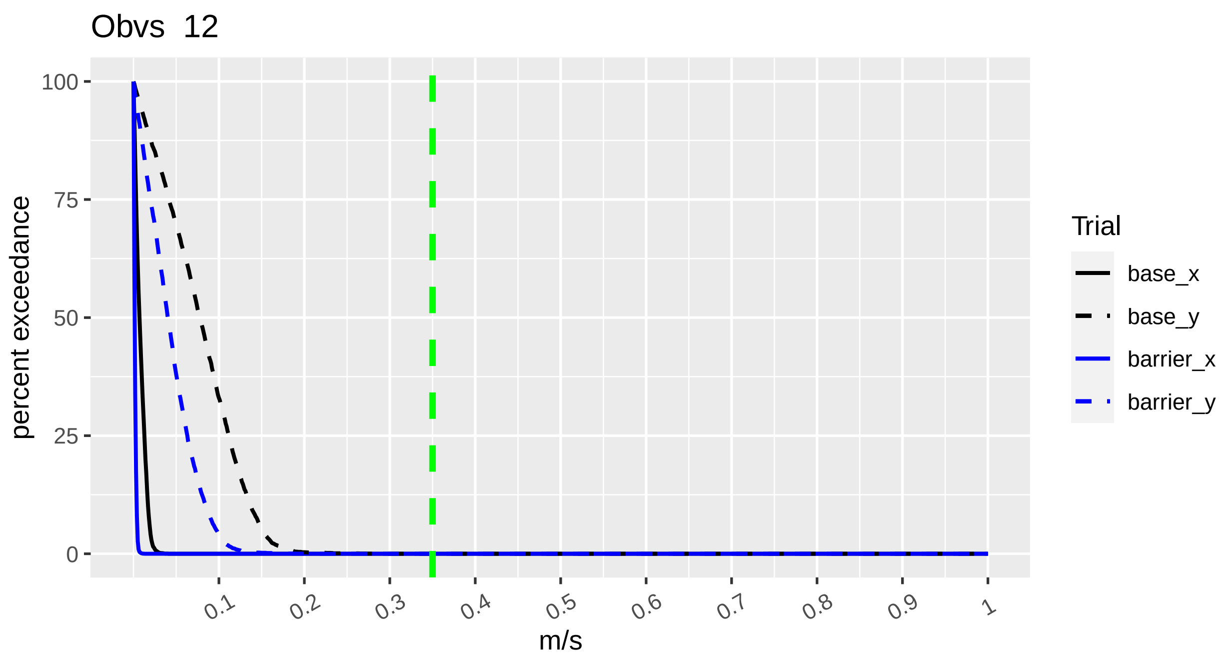


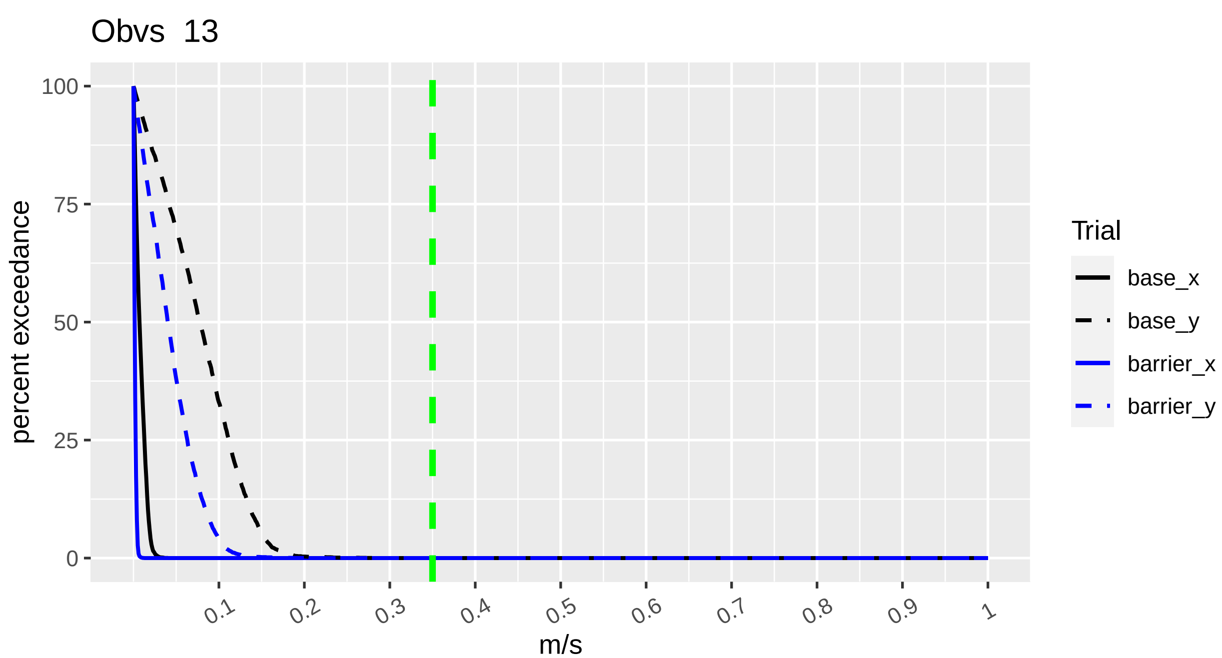
Flow Exceedance

Velocity exceedance plots were also generated and show the percent of the time that the depth-averaged flow exceeds a given velocity in the north-south direction. Previous work by GLO/TAMU has established 0.35m/s as the threshold for erosion of unconsolidated material along the study area shorelines (dashed green line).







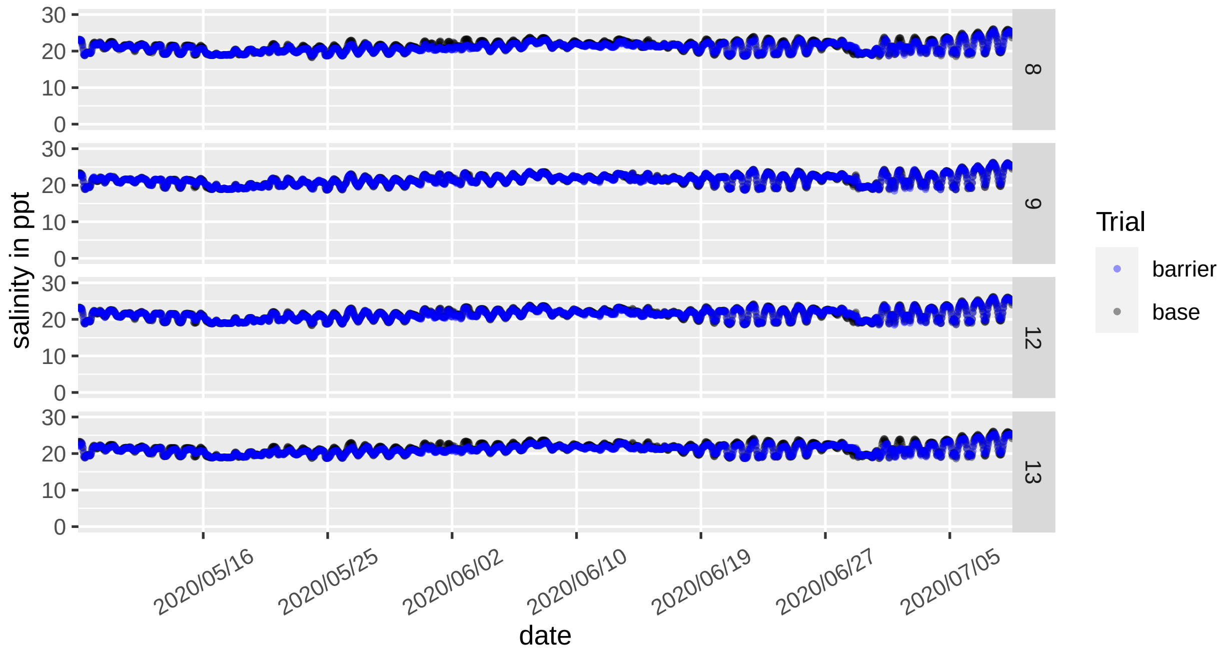


Salinity

The mean salinities for each observation point and trial are shown in the table below. Due to the initilization time of the model only the last 1500 records are analysed.

	baseline ppt	barrier ppt
Obvs_pt_8	21.26	20.99
Obvs_pt_9	21.45	21.44
Obvs_pt_12	21.36	21.31
Obvs_pt_13	21.35	21.08

The last 1500 salinity samples are graphed below.



Summary

Overall, the structure reduces waves out to ~400 m on average in all directions, and generally has a reducing effect on flow velocities. It does slightly increase flow velocities on its southeastern and northwestern flanks out to ~100 m.

This structure reduced the significant wave height in all directions, particularly on the northern side of the structure. It reduced waves on the north side by more than 1/2, and on its east and west sides by ~1/3. The wave protection afforded by the structure generally extended ~400 m away from it, on average, but only rarely provided any protection to the back side of Schicke Point.

The structure greatly reduced the N-S direction average water flow velocities at all observation points (on the cardinal directions N, S, E, W), and the effect was most strongly felt on the northern and western sides. In particular on the north side, velocities dropped from 0.07 meters per second to 0.01. The structure doubled the E-W direction velocities (on the north and south sides), but the absolute increases were relatively small and on the order of 0.01-0.02 meters per second each. All of the changes in velocity occurred well below the critical erosion threshold velocity.

FNI Round Island North

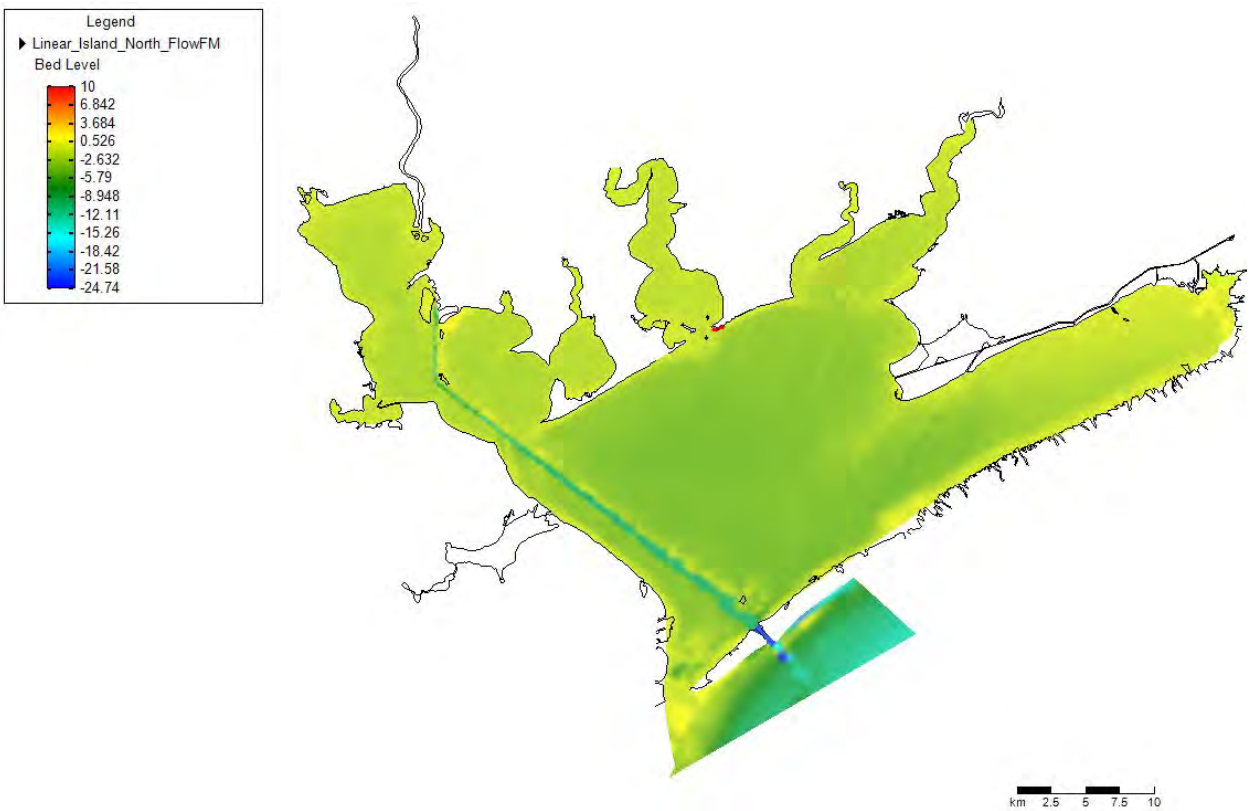
1/24/2022

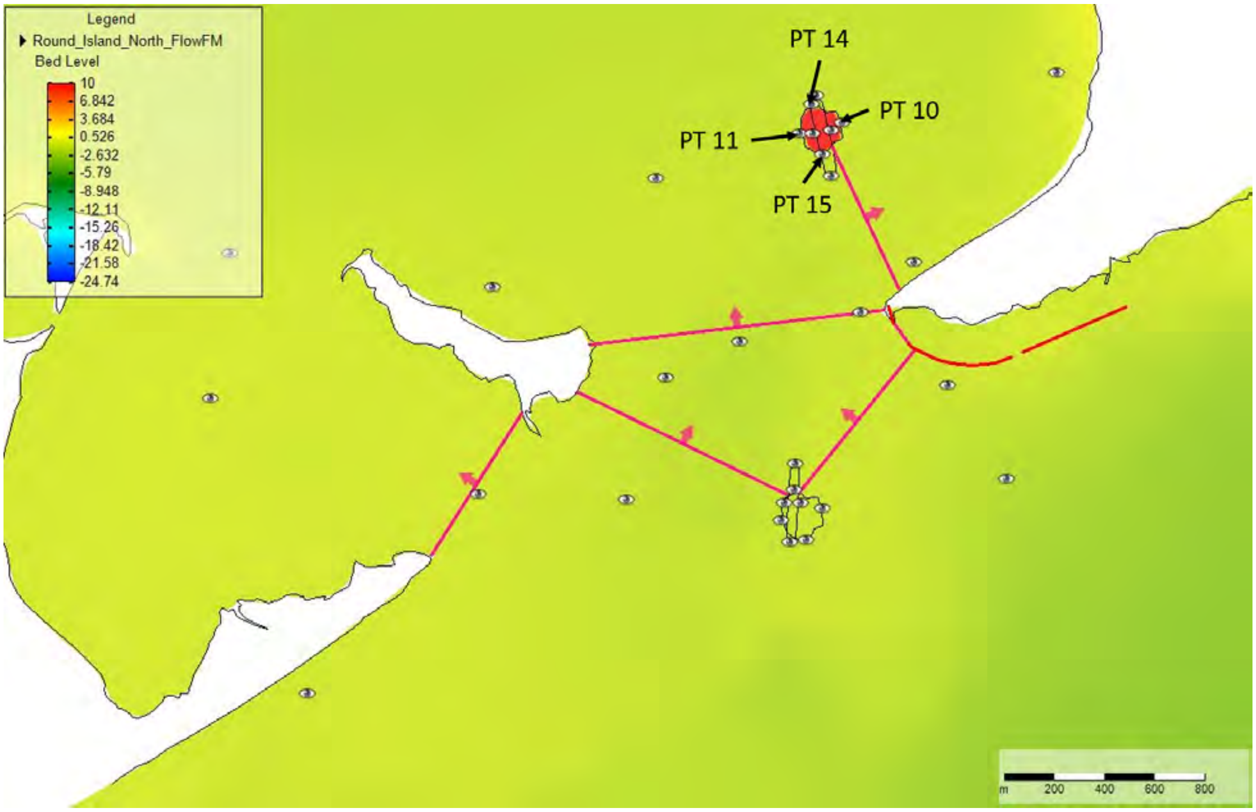
Model Description

Two model runs were conducted using a large scale flexible mesh grid that extended into the Gulf of Mexico. One run simulated a baseline condition that we call "base" and the second that simulated the effect of a long barrier placed along the West Matagorda Bay shoreline that we call "barrier".

Both models were parameterized using GLO/TAMU and NOAA data and covered January to July 2020 dates. Both included wind, waves, depth averaged flow direction and velocity, and salinity. Both used the same forcing parameters with the only difference being the tested structure. The bathymetry was modified to create a "barrier" structure that was 10 m in height, thus overtopping of the structure was not allowed to occur.

Four locations were selected for comparison: observation point 10 (just east of the structure), observation point 11 (just west of the structure), observation point 14 (just north of the structure), and observation point 15 (just south of the structure).



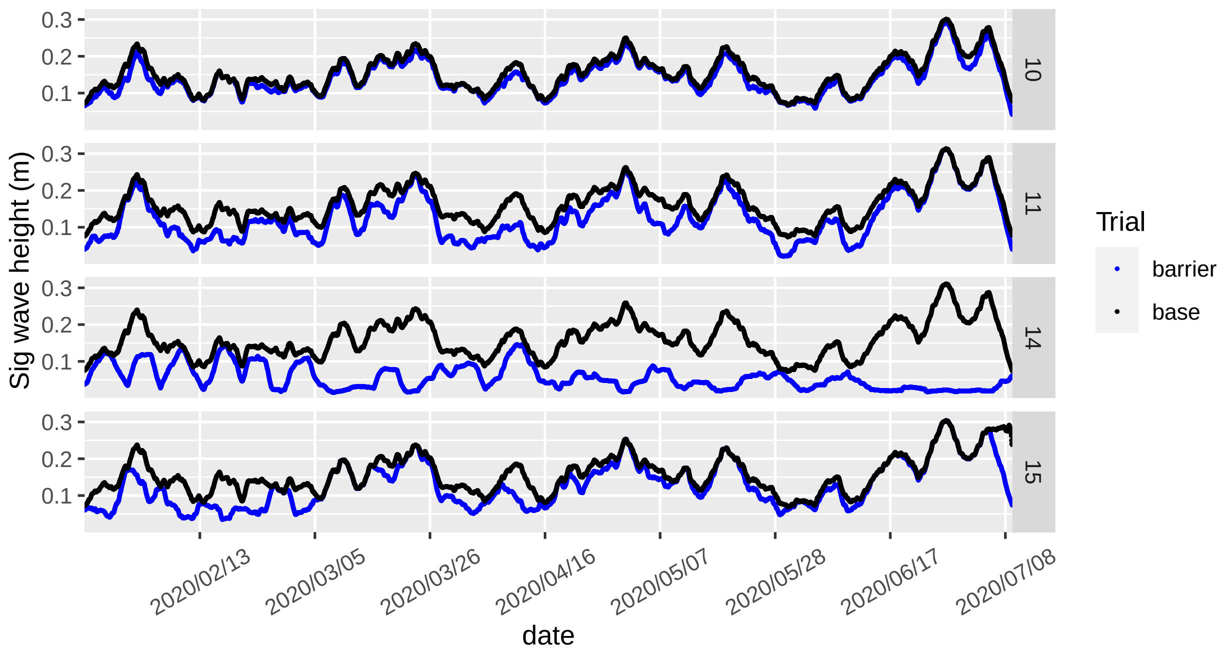


Wave Reduction

The significant wave heights for each observation point are shown in table below.

	baseline Sig wave height	FNI_barrier Sig wave height
Obvs_pt_10	0.15	0.14
Obvs_pt_11	0.16	0.13
Obvs_pt_14	0.16	0.06
Obvs_pt_15	0.15	0.13

The significant wave heights over time are shown below (blue represents the barrier and black the baseline).

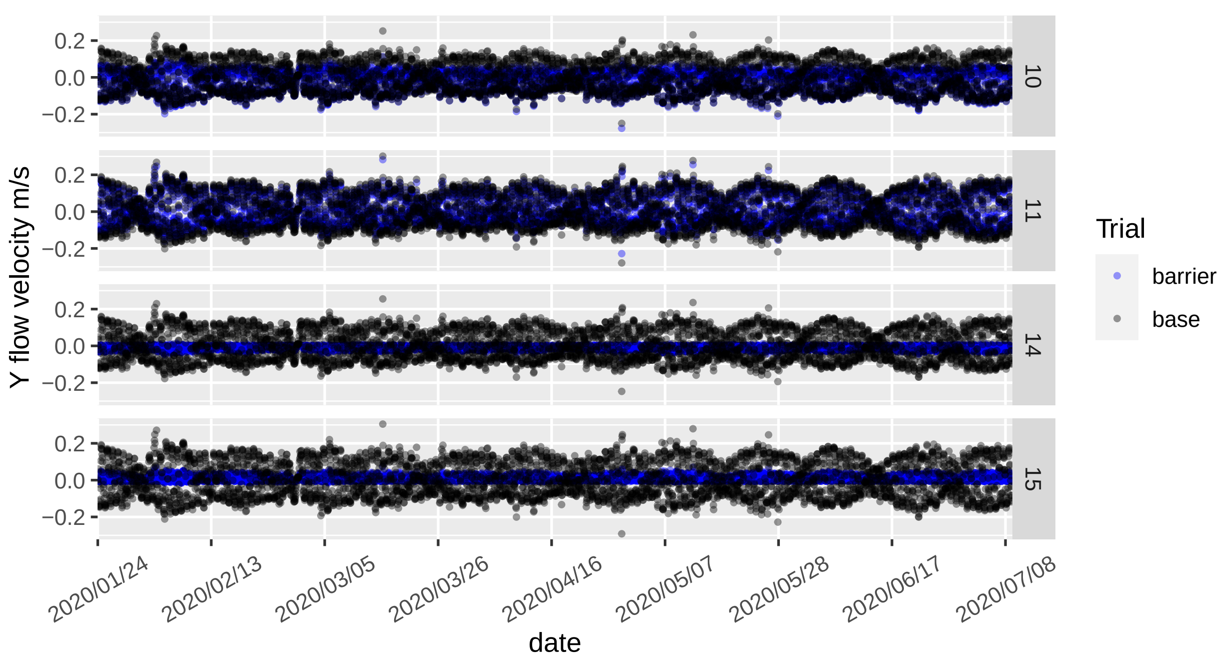


Flow Velocity and Direction

The mean flow velocities in the y direction (north-south) for each observation point are shown below.

	baseline (m/s) Y	FNI_barrier (m/s) Y
Obvs_pt_10	0.07	0.05
Obvs_pt_11	0.08	0.06
Obvs_pt_14	0.07	0.01
Obvs_pt_15	0.08	0.01

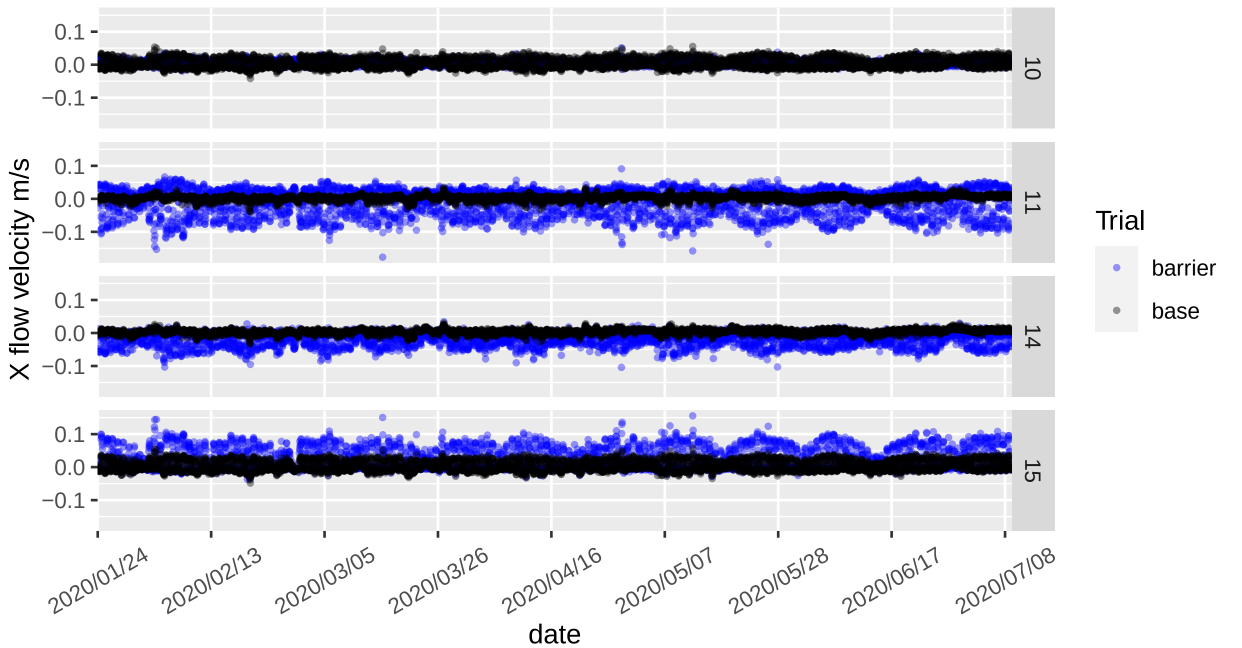
The flow velocities over time in the y direction (north-south) are shown below.



The mean flow velocities in the x direction (east-west) for each observation point are shown below.

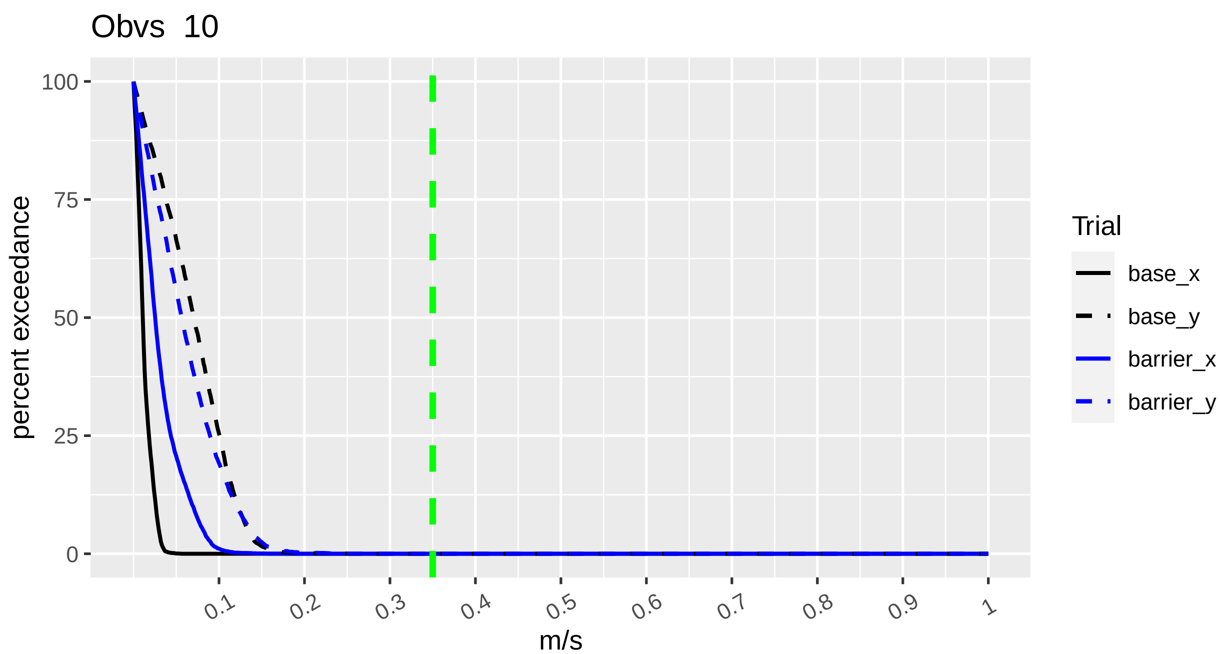
	baseline (m/s) X	FNI_barrier (m/s) X
Obvs_pt_10	0.01	0.01
Obvs_pt_11	0.01	0.03
Obvs_pt_14	0.01	0.02
Obvs_pt_15	0.01	0.02

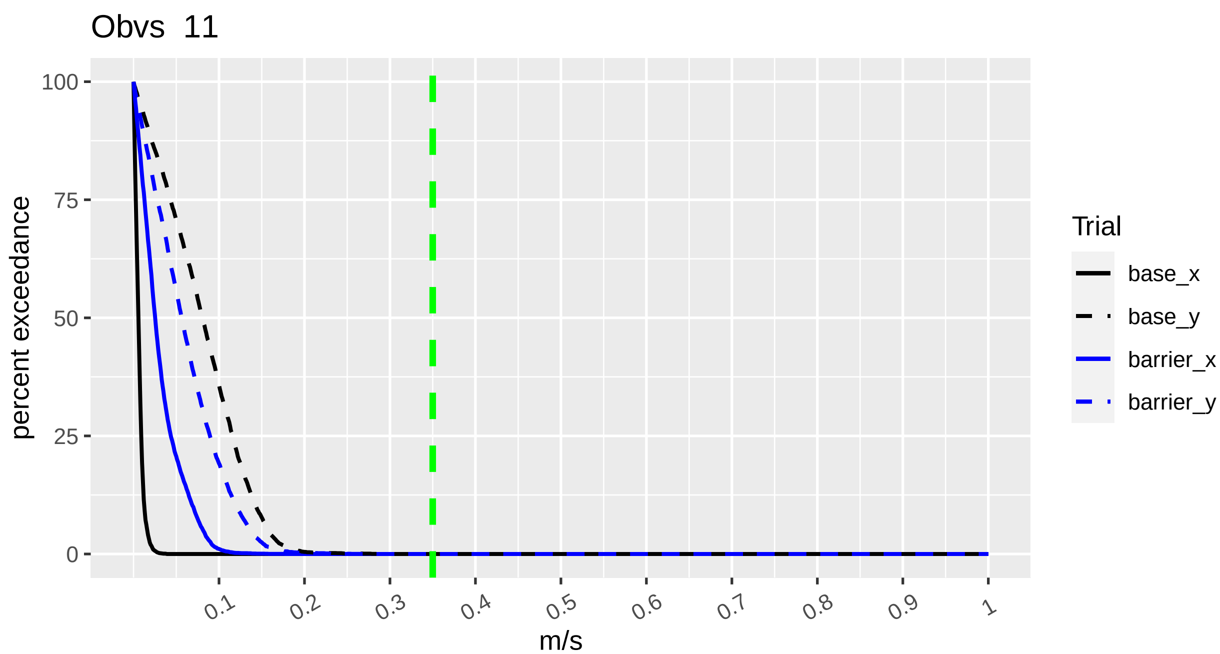
The flow velocities over time in the x direction (east-west) are shown below.

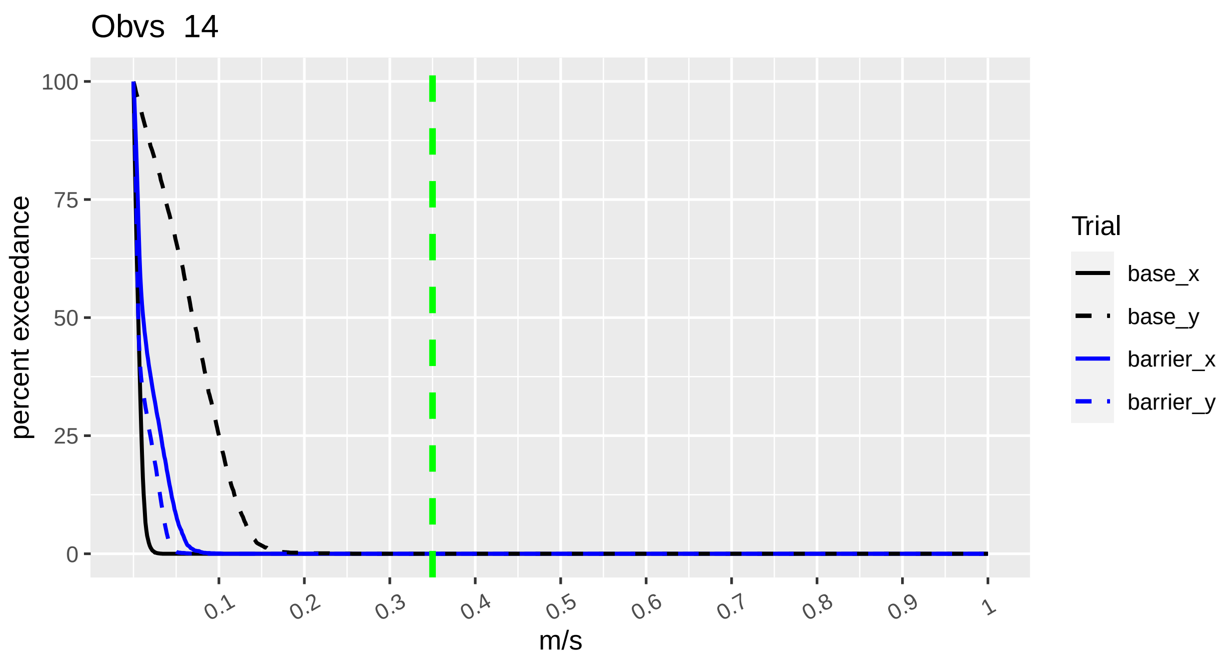


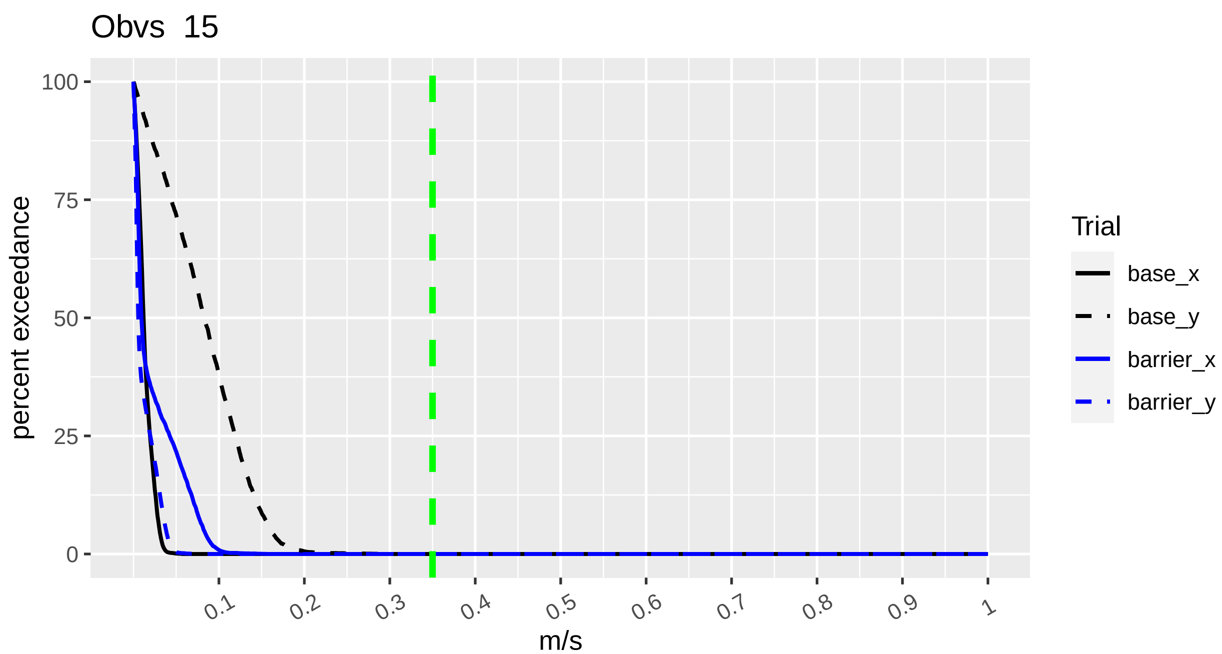
Flow Exceedance

Velocity exceedance plots were also generated and show the percent of the time that the depth-averaged flow exceeds a given velocity in the north-south direction. Previous work by GLO/TAMU has established 0.35m/s as the threshold for erosion of unconsolidated material along the study area shorelines (dashed green line).


Obvs 10
100
75
50
25
0
percent exceedance
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
m/s
Trial
base_x
base_y
barrier_x
barrier_y


Obvs 11
100
75
50
25
0
percent exceedance
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
m/s
Trial
base_x
base_y
barrier_x
barrier_y



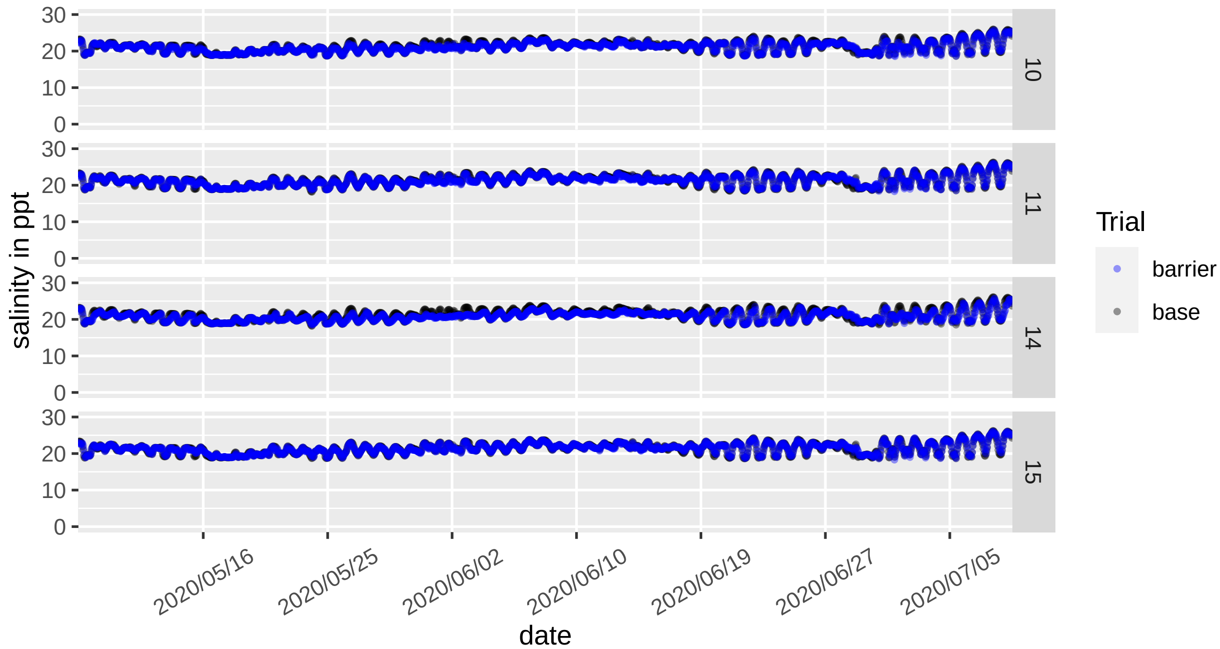


Salinity

The mean salinities for each observation point and trial are shown in the table below. Due to the initilization time of the model only the last 1500 records are analysed.

	baseline ppt	barrier ppt
Obvs_pt_10	21.32	21.11
Obvs_pt_11	21.36	21.28
Obvs_pt_14	21.28	20.87
Obvs_pt_15	21.42	21.42

The last 1500 salinity samples are graphed below.



Summary

Overall, the structure reduces waves out to ~500 m on average in all directions, and generally has a reducing effect on flow velocities. It does slightly increase flow velocities on its southeastern and northwestern flanks out to ~100 m.

This structure reduced the significant wave height in all directions, particularly on the northern side of the structure. It reduced waves on the north side by more than 2/3, and about 1/5 on the other sides. The wave protection afforded by the structure generally extended ~500 m away from it, on average, and provided some protection to the back side of Schicke Point.

The structure greatly reduced the N-S direction average water flow velocities at all observation points (on the cardinal directions N, S, E, W), and the effect was most strongly felt on the northern and southern sides. In particular on the north side, velocities dropped from 0.07 meters per second to 0.01. The structure doubled the E-W direction velocities on the north and south sides and tripled them on the west side, but the absolute increases were relatively small and on the order of 0.01-0.02 meters per second each. All of the changes in velocity occurred well below the critical erosion threshold velocity.

Appendix B: August 2023 Stakeholder Meeting

Carancahua Bay Mouth Rookery Island Meeting 8/7/23

Attendees:

- Matt Salmon, FNI
- Tam Tran, FNI
- Bill Balboa, Matagorda Bay Foundation
- Meghan Martinez, GLO
- Leslie Hartman, TPWD
- Rita Setser, GLO
- Kelly Brooks, GLO
- David Buzan, FNI
- Woody Woodrow, USFWS
- Alexis Baldera, Audubon Texas
- Sydney Fox, Audubon Texas

Overview of Feasibility Study + Application Process

Progress + Timeline – ideal construction start date around 2024/25

Two locations were considered:

- Inside of the mouth
    - bottom sediment consists of mostly mud/clay
        - used PVC pipe to measure resistance
        - soft mud was about a foot – firm was 6 inches or less
    - water depths approx. 3 feet
    - no oysters SAV
    - heard there was more recreational boating traffic inside of the mouth of the bay (managing for human disturbance is one of the hardest things to control)
- Outside of the mouth
    - found more firm sands and similar shallow depths
    - *Further away from predators and human disturbances*
    - ***selected this location – looked at both areas in a numerical model and saw there was not much difference between the two besides the clay (no change to the hydrodynamics of the inlet)***

Feasibility study – size/shape

- selected round island because it gave more opportunity to create sloped island to maximize land/water interface for shorebirds
- each alternative was found to have no measured effect on waves or flow velocities
- each alternative reduced wave heights near the structure but did not affect waves or currents at the shoreline
- about 1.7 acres of habitat
- top elevation +6 feet – best elevation to design rookery islands is 10% AEP
- 20-year life including sea level rise
- lots of sand in the area – easy for dredge

**cost estimate ~ $4 million

Summary of feasibility study/where we are now:

- Purpose is the improve bird habitat in Matagorda Bay
- Comprehensive technical committee analyzed 30+ sites and Carancahua Bay was one of the most preferred
- Best location found to be outside of the Carancahua Bay
- Application is being reviewed by the Army Corp of Engineers

Questions/Comments

- Can we conduct a projected cost analysis looking at 1.7 acres – could cost less per unit to build slightly larger? 1.7 vs. 2.5 vs. 3
    - Did preliminary cost analysis on round vs elongated vs small/large.
- Size of island where predation goes up?
    - Larger than 5 acres plus closer to shore
- David Buzan – did siting analysis and literature suggests that an island smaller than 5 acres area may be more appropriate – initial feasibility analysis compared cost of 2 different sizes of round island – at the time it happened (several years prior to Matt's analysis) 1.7-acre island was going to be $4 mil and 5 acre would be $7 mil. The Feasibility Study found cost savings per acre for the larger island footprint with an average cost of approximately $2.5 million / acre for small and $1.5 million / acre for large.
- Would probably get pushback on a larger island (TPWD) – **people have been leasing in the area for oyster mariculture** – work with Emma to put off limits to mariculture—1.7 easy to work mariculture around it
    - Distance requirements on mariculture? – navigable waterways + distance from shoreline
    - Currently 2-3 people trying to get into mariculture in the East Matagorda Bay area
    - https://tpwd.maps.arcgis.com/apps/MapSeries/index.html?appid=7a7745f57afd4aeebb18fd3ac60fe751

Concerns?

- Make sure Bob Friedrich and Brent Ortego are aware of plan
- Considering planting native plant species – Philip Smith, GBF, and Scott Alford, are contacts for the native plant list and possible sources of plants
- There is a development in the general area – Port Alto Association (talk to residents) – get people in CBC to discuss with locals and spread the word
- Talk to Palacios school district for volunteers with planting
- Turtle Creek aquaculture farm can help provide plants too
- CBS survey was done for Schicke Point extension project (2017)
- Best interest of GLO to have coastal boundary done post 2017 because of private landowners on both sides of the mouth (Kelly + Meghan getting in contact with GLO survey and legal to let us know if we need to pursue this)
- Island reducing erosion to shoreline? It would need to be much larger to make an actual impact – it will cast an energy shadow where it will reduce energy a few hundred yards away from island where waves are, but no legitimate effect on shoreline
- Concern about how small the island is and how much habitat it can provide for birds to take the stress/density out of Chester island?
    - 1-acre island can provide habitat for several hundred nesting pairs; feasibility study included new bird habitat and other alternatives; we're trying to bring other islands back online to steward
- TPWD wants more marsh built in the area
- Not sustainable to build/restore bird islands for $2 million an acre—is there a way to use/enhance current existing places (shell reefs?)
- Get Matagorda CCA in the loop/on board

Next steps:

- GLO, Meghan, will determine if a coastal boundary survey is required.
- Confirm who will send KMZs of the island and borrow sites to Emma Clarkson at TPWD to minimize use conflicts with possible oyster mariculture facilities. Important to do before a potential oyster mariculture facility reserves the location.
- Archeological study / Cultural Resources Survey for permit.
- Funding for the island

Amended with USFWS feedback received on 08/15/2023

- The engineer said that the model is Evia Island. In Hurricane Ike, Evia Island was perhaps the only habitat project that had impacts in Galveston Bay. Very large revetment stones were cast about by the currents and waves. All the other structural projects that I flew over were all under the water at the peak of the storm and by the time the water elevation settled on them, the energies were back to normal. Long-term flooding or near coastal habitat projects was the only other impact we could find. It was not cheap to fix Evia after the storm.
- Are you confident that +6.0' NAVD is the right target elevation? Did Audubon (not the engineer) compare this elevation to data collected from the site or at Schicke Pt. empirically or a NOAA tide station? Did the engineer explain that every increment in height disproportionally affects material volume and cost? While

we did increase the height of Dressing Point and Rollover Bay Islands by 1 foot to +5.0 NAVD, this change was based on empirical data from events during the breeding season at both locations. Since this project is hydraulically dredging, did they discuss the need for containment levees that exceed +6 ft? Was the option of importing dry material (sand) from a known permitted source like a sand quarry? Containment of fluid is not needed.

- What level of storm are you trying to protect against? Was there any discussion of the tradeoff between longevity and cost?
- Which species are you targeting?
- Despite the permit application has been submitted, Audubon can change the design as long as the impacts are less without submitting for an amendment. Therefore, you still have the option of changing some things through the solicitation for bids process. A good engineer can include alternate bid items, for example, ask one for hydraulic dredging and another for importation of material or different heights, etc. This is one way to tweak the costs associated with the project and make choices when the bids come in. GLO staff are great. Rely more on them than the engineer. They will help you.
- Please get geotechnical work done as a priority because that can change the project significantly. I was a bit surprised that he did not know about penetrometers or the weight of rod. He tried to recover from that comment, so he pulled out "cone" penetrometer which is similar and uses the same principle, but it was pioneered by Fugro and used more for buildings and infrastructure foundations. As a field technician, I was taught by civil engineers who spent lots of time in the field.
- When Dave Busan relayed that the literature suggests that 5 acres or less is ideal, do you know the source he is referring to and have you read the source yourself? I have read a paper on this subject, and I do not know if I agree with Dave's statement in every case.
- A 1.7-acre nesting island where there never was one and not even one nearby that costs over $2M an acre in a location where it will be possibly subject to challenging conditions is difficult to justify when there are other sites in great need.

Appendix C: 90% Design

Innovative approaches
Practical results
Outstanding service

90% DESIGN - CARANCAHUA BAY MOUTH ROOKERY ISLAND

Prepared for:

Audubon Texas

June 6, 2023

Funded by:

Texas Coastal Management Program

National Oceanic and Atmospheric Administration

Prepared by:

FREESE AND NICHOLS, INC.
10431 Morado Circle, Suite 300
Austin, Texas 78759
512-617-3100

Innovative approaches
Practical results
Outstanding service

90% DESIGN - CARANCAHUA BAY MOUTH ROOKERY ISLAND

Prepared for:

Audubon Texas

DRAFT

THIS DOCUMENT IS RELEASED FOR THE PURPOSE OF INTERIM REVIEW UNDER THE AUTHORITY OF **Matt Salmon**, P.E., TEXAS NO. **143709** ON 6/6/2023. IT IS NOT TO BE USED FOR CONSTRUCTION, BIDDING OR PERMIT PURPOSES.
FREESE AND NICHOLS, INC.
TEXAS REGISTERED ENGINEERING FIRM F- 2144

Prepared by:

FREESE AND NICHOLS, INC.
10431 Morado Circle, Suite 300
Austin, Texas 78759
512-617-3100
ADB22691

TABLE OF CONTENTS

Table of Figures

Table of Tables

APPENDICES

1.0 INTRODUCTION

This report documents the engineering design of a rookery island (Project) near the mouth of Carancahua Bay in Calhoun County, Texas. The purpose of this project is to increase the resiliency of colonial nesting waterbirds on the central Texas coast. The Project area is shown in Figure 1 and Figure 2, as well as a nearby potential project that could armor Redfish Lake to reduce erosion.

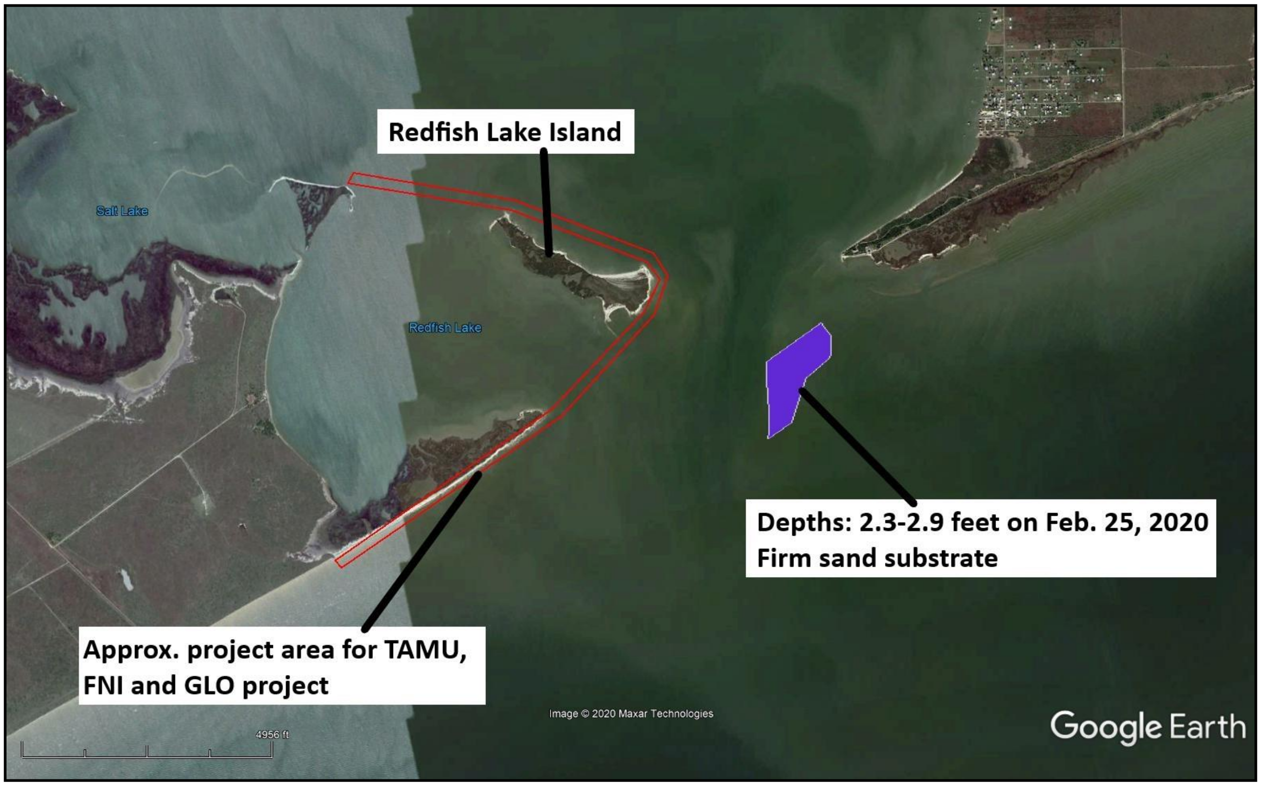


Figure 1: Project Site and Vicinity

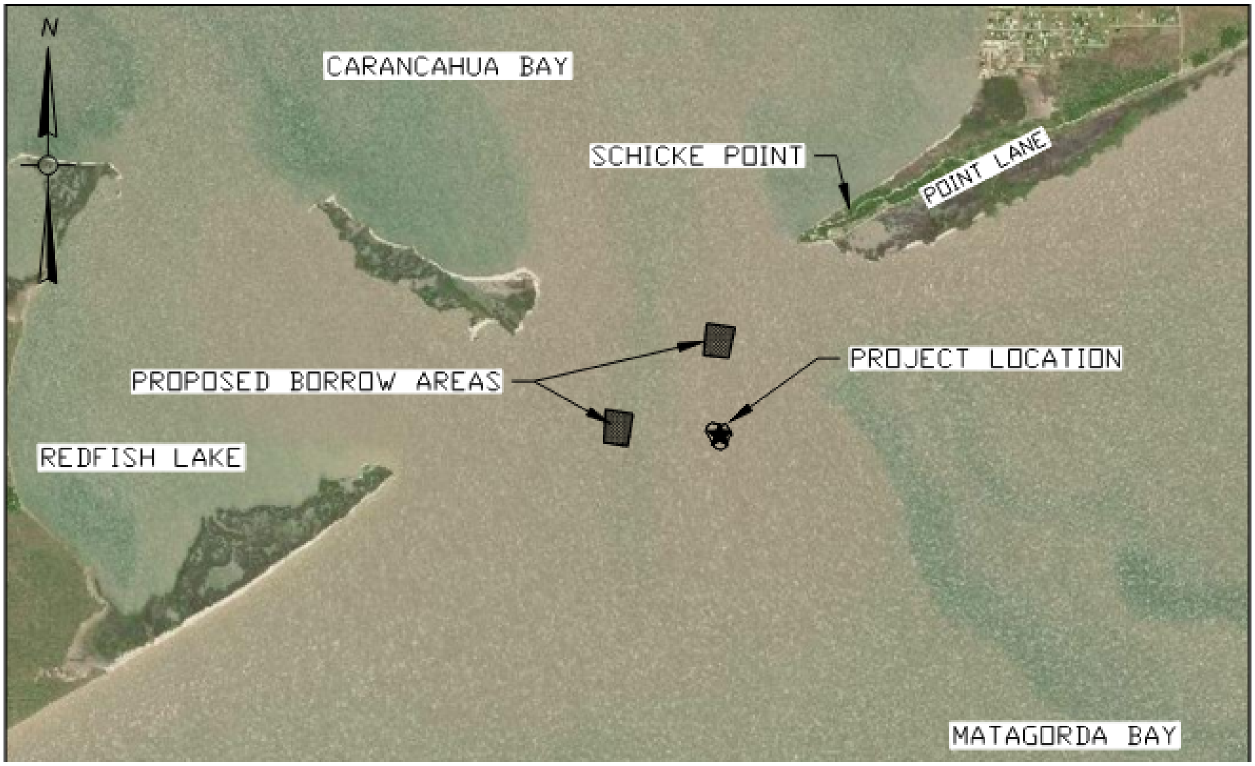


Figure 2: Project Footprint and Location

1.1 BACKGROUND

Audubon Texas (Audubon) contracted Freese and Nichols, Inc. (FNI) to design a new bird island in Matagorda Bay at the mouth of Carancahua Bay in Calhoun County, Texas. A previous Feasibility Study (FNI 2020), completed by Audubon and FNI, identified the project area as acceptable based on considerations for location, biology, and design. The location meets the following criteria:

- Substantial geographic separation from other central coast rookery islands (at least 8 miles from the nearest island rookery),
- Minimum distance of 0.2 miles from land to decrease the likelihood of terrestrial predators (e.g., racoons, coyotes, feral hogs, etc.) accessing the island, and
- Located a significant distance from the Matagorda Ship Channel which likely protects the island from a spill (oil, chemical, etc.) in the ship channel (i.e., the most likely place for a spill to occur).

The area's biology was assessed to confirm:

- Various populations of colonial nesting waterbirds foraging and loafing in the areas near the proposed island which would be likely to select it for nesting,
- Access to foraging sites like shallow tidal pools, oyster reefs, and marsh at Schicke Point and Redfish Lake may allow nesting birds to focus more energy and time on nesting and care of fledgling birds, and
- No observed seagrass beds or oyster reefs are in the proposed project footprint.

The project area meets the following design considerations:

- Sediment substrate in the area is firm sand,
- Water depths within the project area are less than 3 feet,
- Site can be easily accessed by construction equipment and biologists for monitoring, and
- Potentially helps protect the mouth of Carancahua Bay from wave erosion by adding a barrier to waves generated over the open water fetch across Matagorda Bay.

1.2 DESIGN CRITERIA

The Feasibility Study (FNI 2020) analyzed four island alternatives including two linear and two round islands. This Study selected the Small Round Island alternative to carry forward to engineering and design. A key factor influencing selection of this alternative was Audubon's goal to create an island which would structurally support habitat for shrub nesting and ground nesting birds. A narrow, linear island might not have enough space for the topographic diversity needed to support growth of shrubs.

The selected alternative consists of a round island with a nesting area of approximately 1.7 acres. Design of the island includes meeting the following criteria:

- Maximize habitat for shrub and ground nesting birds,
- Maximum and minimum island elevations of +6 feet and -2 feet NAVD88, respectively.
- Provide sloped beach of island for water access in the intertidal zone (i.e., MHHW to MLLW).
- The constructed area should be a minimum of 1.7 acres.
- Scour protection provided by armor stone.
- Island fill to utilize locally available borrow material.
- 20-year design life for storms and sea level rise.

2.0 ENGINEERING DESIGN

The design of the island includes defining project area design conditions including the project area existing elevations, water levels, sea level rise, wind speed, and wave heights. Each of these conditions is utilized to calculate a stable armor stone size and section to reduce erosive forces.

2.1 PROJECT DESIGN LIFE

Project design life is the amount of time a project is intended to function with limited maintenance. The typical design life for coastal restoration projects is 20 years post construction. This design life was selected for this project. This is the standard design life utilized by other Gulf Coast states implementing environmental restoration. For design comparison, the rookery island calculations include development of design criteria for an event with an annual exceedance probability (AEP) of 99% (1-year), design life event 5% AEP (20-year), and extreme event 2% AEP (50-year). These three design events were selected to design the island for normal conditions (99% AEP), design life conditions (5% AEP), and extreme conditions (2% AEP). The design shall require no to limited maintenance after a frequent and/or design life event and will require maintenance after an extreme event.

2.2 EXISTING ELEVATIONS

A project design survey was completed by T. Baker Smith on November 8, 2022. The survey found that bottom elevations within the project area range from -1.6 to -2.5 feet NAVD88. A copy of the survey is included in Appendix A.

2.3 WATER LEVELS

Project specific water levels refer to calculated water elevations based on local datums and annual exceedance probability storm surge. Local water elevations are reported at NOAA Gauge 8773701 located at Port O'Connor, the nearest gauge to the project area (NOAA 2022). Water elevations for local datums including MHHW, MSL, and MLLW, relative to the NAVD88 datum, are shown in Table 1. These water elevations will be utilized to define the working range of on-water construction equipment.

Table 1: Water Elevations at Port O'Connor NOAA Gauge 8773701

Datum	Elevation (feet, NAVD88)	Description
MHHW	1.10	Mean Higher High Water
MSL	0.78	Mean Sea Level
MLLW	0.38	Mean Lower Low Water
NAVD88	0.00	North American Vertical Datum of 1988

Storm surge water elevations are reported in the Calhoun County Flood Insurance Study (FIS) (FEMA 2018). The FIS reports anticipated storm surge for 10% (10-year) and 2% (50-year) AEP. 99% and 5% AEPs were interpolated assuming a best fit power curve. Reported and interpolated storm surge elevations are shown in Table 2.

Table 2: FEMA FIS Storm Surge Elevations for Calhoun County

AEP (%)	Return Period	FEMA SWEL (feet NAVD88)
2	50	8.9
5	20	7.0
10	10	5.8
99	1	3.8

*Shaded cells are interpolated from reported data.
Acronyms: SWEL (still water elevation)

2.4 SEA LEVEL RISE

Sea level rise (SLR) estimates are calculated at NOAA for gauges with long-term records (NOAA 2023). The two nearest gauges to the project area with long-term records are located at Rockport, Texas approximately 60 miles southwest of the project (see Table 3) and Freeport, Texas approximately 63 miles northeast of the project area (see Table 4). For design, the more conservative SLR calculations at the Freeport gauge are used since SLR estimates are higher than Rockport. Intermediate-low SLR is selected for this design as this is the most used scenario for similar projects along the Texas coast designed by USACE. SLR elevations for Intermediate and High are shown for reference. NOAA calculates SLR estimates in 20-year increments (e.g., 2000, 2020, 2040, etc.). Design water levels between these increments were linearly interpolated using the SciPy interp1d toolbox within the Python programming language (SciPy 2020).

Project design criteria assume construction would start in 2025 (project year 0) and the design life would extend to 2045 (project year 20). It is assumed that this engineering design shall be completed in 2023 and it will likely take some time to secure a contractor and begin construction, thus a start in 2025. The anticipated amount of SLR estimated to occur from 2025 to 2045 is 0.89 feet. Wind, wave, armor stone and toe design parameters and criteria hereafter apply and account for this projected sea level rise.

Table 3: Sea Level Rise in Feet Rockport, Texas

Scenario	2000	2020	2040	2060
Intermediate-Low	0.00	0.56	1.21	1.87
Intermediate	0.00	0.59	1.28	2.10
High	0.00	0.59	1.44	2.92

Table 4: Sea Level Rise in Feet Freeport, Texas

Scenario	2000	2020	2025	2040	2045	2060
Intermediate-Low	0.00	0.66	0.86	**1.44**	1.75	2.23
Intermediate	0.00	0.69	-	1.51	-	2.46
High	0.00	0.69	-	1.67	-	3.28

2.5 WIND SPEEDS

National Data Buoy Center (NDBC) Gauge PTAT2 located at Port Aransas, Texas has a wind record that extends from 1984 to 2022 (39 years). This wind gauge record is utilized to design wind direction and speeds and direction. The gauge's most common wind direction is 135 degrees from true North, approximately Southeast. A wind rose of the gauge record is shown in Figure 3.

Design wind speeds were calculated by fitting annual maxima to a general extreme value probability function. This is a typical method to calculate annual exceedance probability (AEP) wind speeds. Wind speeds from American Society of Civil Engineers (ASCE) 7 Hazards Tool were considered, but they were ultimately not selected because the standard coastal equations are not intended to utilize wind speeds specified for structural design. Wind speeds used for design are shown in Table 5 (SciPy 2020).

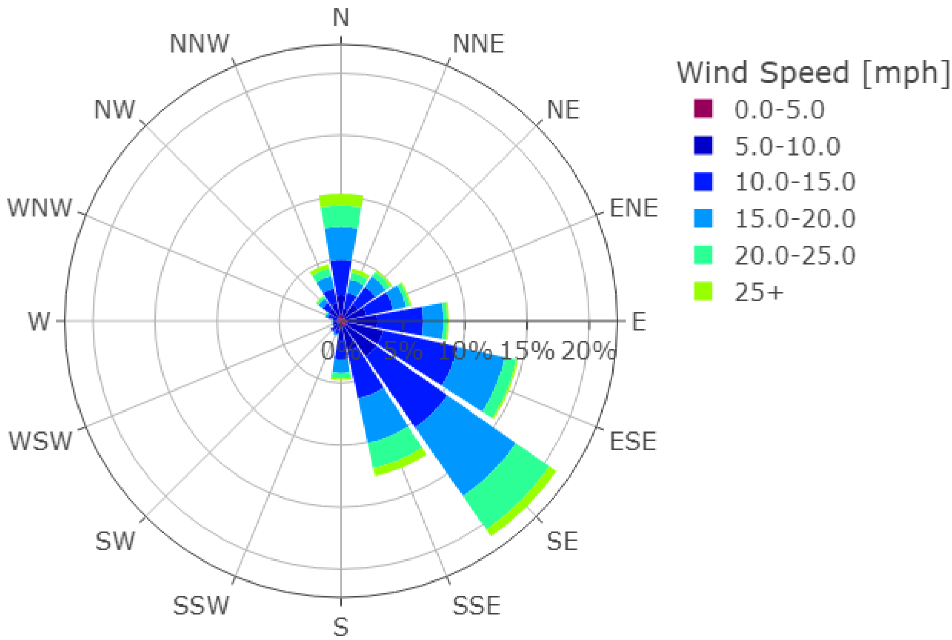


Figure 3: Wind Rose for NDBC Gauge PTAT2

Table 5: Annual Exceedance Probability Wind Speeds

Annual Exceedance Probability (%)	Recurrence Interval (years)	Wind Speed (mph)
50%	2	39
5%	20	54
2%	50	62

2.6 WAVE HEIGHTS

The ACES Software (Leenknecht 1992) calculates wind generated wave height and period using improved methods from the Shore Protection Manual (SPM) (CERC 1973) and other empirical formulae as described in the U.S. Army Corps of Engineers Coastal Engineering Manual 1110-2-1100 Part II (USACE 2007). Fetch limited wave growth formulae are significantly dependent upon radial fetch geometry, fetch depth, wind speed and direction. Radial geometry was developed using radial angle increments of 30° centered at the project location near the Port O'Connor NOAA gauge, see Figure 4. Similarly, the bottom elevation along the fetch radial extending across Matagorda Bay of -11.3 feet NAVD88 was used to represent fetch depth, which also includes considerations for AEP water elevations and sea level rise for the design water depth. The prevailing wind speed and direction were determined as described in the **Wind Speeds** section. See Table 6 and Table 7 for wave heights, periods, and still water elevations with SLR utilized for design.

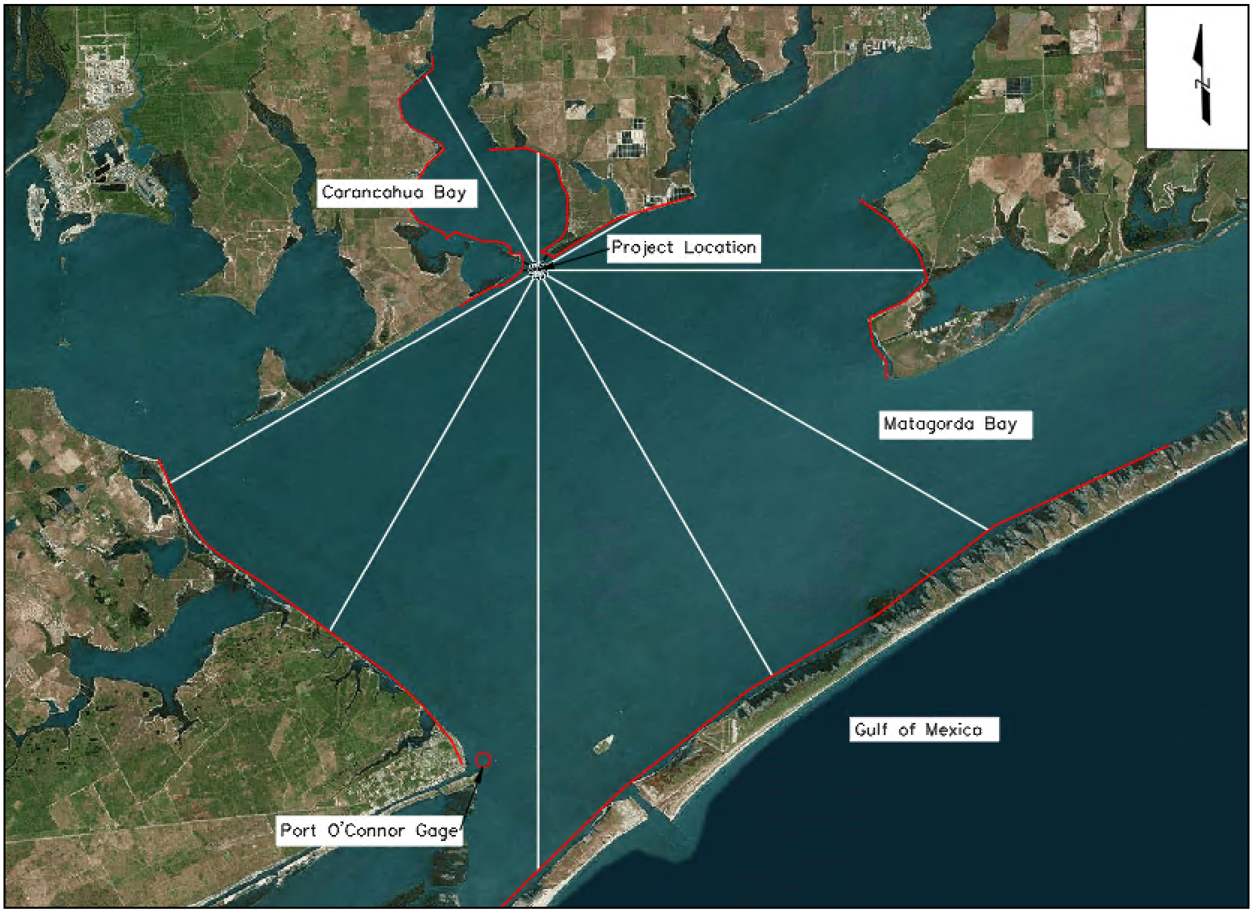


Figure 4: Fetch Radial Geometry for Project Area

Table 6: Year 0 (2025) ACES Calculated Design Wave Height and Period

Recurrence Interval (years)	Wave Height (feet)	Wave Period (seconds)	Still Water Elevation (feet NAVD88)[1]	Water Depth (feet)
2	3.1	3.5	4.4	15.7
20	4.5	4.2	7.0	18.3
50	5.4	4.6	8.9	20.2

1. SWEL includes considerations for Intermediate-Low SLR.

Table 7: Year 20 (2045) ACES Calculated Design Wave Height and Period

Recurrence Interval (years)	Wave Height (feet)	Wave Period (seconds)	Still Water Elevation (feet NAVD88)[1]	Water Depth (feet)
2	3.2	3.5	5.3	16.6
20	4.5	4.2	7.9	19.2
50	5.5	4.6	9.8	21.1

1. SWEL includes considerations for Intermediate-Low SLR.

2.7 ARMOR STONE SIZING

The project requires two armor stone designs, one for a revetment that rings most of the island and one for a breakwater that surrounds the intertidal area. The ACES software is used to calculate armor sizes utilizing the revetment method, as well as Hudson and Van der Meer methods for non-submerged breakwaters. An additional method, Van der Meer for submerged breakwaters, is implemented for 20- and 50-year design to calculate submerged armor sizing. Once breakwater stone is submerged, it is less affected by wave orbital velocities as surge levels rise above them, and standard methods do not account for this.

Each method utilizes a dimensionless stability number to determine the effectiveness of a breakwater structure under wave action. While Hudson is the more conservative method, each method depends on wave height, density of armor unit (165 lb/ft^3), and slope of the breakwater structure (2H:1V). Additionally, revetment and Van der Meer methods include wave period, nearshore slope, and water depth at toe of structure. In the cases where surge elevation would overtop the breakwater structure, a reduction factor based on freeboard was applied. Conversely, when the breakwater structure is not overtopped another stability formula is employed. Table 8 and Table 9 shows the results of the armor size calculations.

Table 8: Year 0 (2025) ACES Calculated Design Armor Stone Size

Recurrence Interval (years)	Median Stone Diameter D_{50} (ft)			Median Stone Weight W_{50} (lbs)		
	Revetment	Hudson	Van der Meer[2]	Revetment	Hudson	Van der Meer
2	1.1	1.0	0.9	226	180	131
20	See Footnote 1	1.1	1.1	See Footnote 1	228	228
50	See Footnote 1	1.1	1.1	See Footnote 1	228	228

[1]The revetment method does not account for submerged structures.
[2]Van der Meer for submerged breakwaters applied for 20- and 50-year.

Table 9: Year 20 (2045) ACES Calculated Design Armor Stone Size

Recurrence Interval (years)	Median Stone Diameter D_{50} (ft)			Median Stone Weight W_{50} (lbs)		
	Revetment	Hudson	Van der Meer[2]	Revetment	Hudson	Van der Meer
2	1.3	1.0	0.9	240	180	130
20	See Footnote 1	1.0	1.0	See Footnote 1	180	180
50	See Footnote 1	1.1	1.1	See Footnote 1	194	194

[1]The revetment method does not account for submerged structures.
[2]Van der Meer for submerged breakwaters applied for 20- and 50-year.

2.8 ARMOR TOE AND CREST DESIGN

Typical toe and crest armor for a revetment are designed to be sacrificial and fill scour holes to prevent armor undermining (CIARA 2007). Typical toes and crests are designed with the same armor thickness as the rest of the revetment with a width that ranges from three (3) times the median diameter up to three times the potential scour depth. This type of toe protection is called “launchable” because the armor stone is intended to immediately launch itself (i.e., fall with gravity) into a scour hole as it forms to reduce the likelihood that scour impacts the main structure. They can be designed to either key into the or an existing slope, or they can be placed above the ground level with a sufficient width to cover the anticipated scour hole. This design for the launchable toe uses the placement above ground level method.

The USACE Coastal Engineering Manual provides two methods for calculating wave generated scour on vertical seawalls. One of them is a “Rule of Thumb” method that estimates scour depth based on wave height, and the second is based on physical modeling tests of “Standing Waves” on vertical walls. There is not a method specifically for sloped revetments, but it is understood that the vertical walls generate a larger reflected wave resulting in increased scour. Calculated scour depths are shown in Table 12

Table 10: Wave Generated Scour Depth

Recurrence Interval (years)	Wave Scour Depth (feet)	
	Rule of Thumb	Standing Wave
2	0	0.3
20	0	0.7
50	0	0.9

Table 11: Revetment Toe and Crest Design Widths

Recurrence Interval (years)	Toe Width (feet)		Crest Width (feet)
	$3*D_{50}$	3*Scour Depth	$3*D_{50}$
2	3.9	0.9	3.9
20	3.3	2.1	3.3
50	3.3	2.7	3.3

2.9 DESIGN CROSS-SECTION AND CONSTRUCTABILITY

The rookery island shall consist of an island constructed to an elevation of +6 feet NAVD88 and an armor layer to reduce erosive forces, per criteria set in Feasibility Study. An aerial view of the island is shown in Figure 5. Island fill shall consist of in-situ sediment dredged from a nearby borrow source that the GLO TxSed database has shown contains primarily gravel and sand (GLO 2023). These assumptions will be confirmed through geotechnical soil testing.

The island consists of two armor sections that include a breakwater and revetment. The breakwater is designed with a crest elevation of +6 feet NAVD88, crest width of 3 feet, and side slopes of 2:1 (H:V), see Figure 6. The revetment is designed to crest elevation of +6 feet NAVD88 with a minimum crest width of 3.9 feet, slope of 2:1 (H: V) and minimum launchable toe width of 3.9 feet, see Figure 7. The median stable armor stone size was calculated to be approximately 1.3 feet in diameter resulting in approximate armor stone minimum thickness of 3 feet to achieve a minimum of two diameters thickness. The design cross-section for the entire island, Figure 8, shows that sediment fill shall be placed in a manner that it slopes at approxima tely 10:1 (H: V) from an elevation of +6 feet NAVD88 to the natural bottom to provide an intertidal area for wading birds.

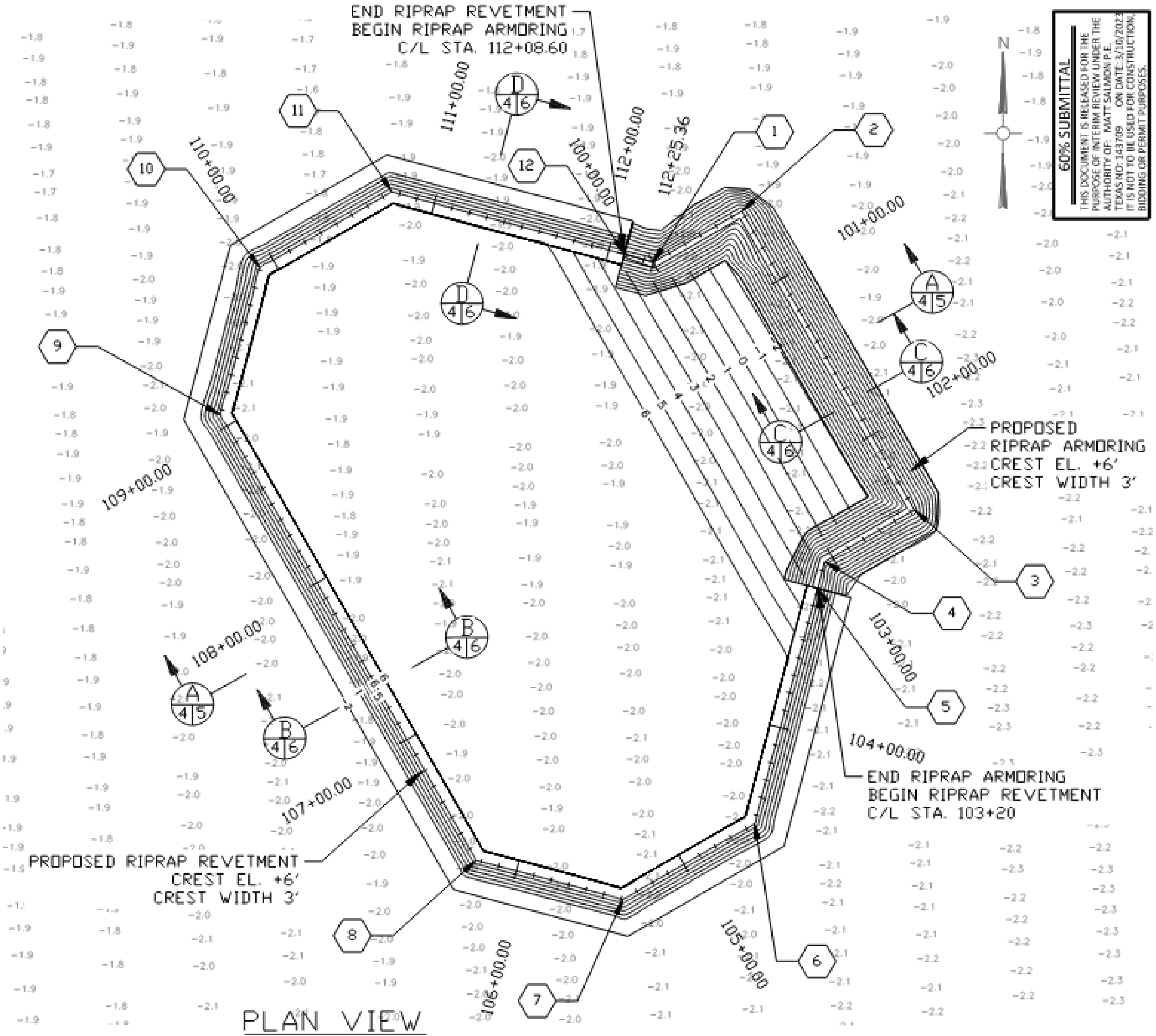


Figure 5: Plan View of Rookery Island for Permitting

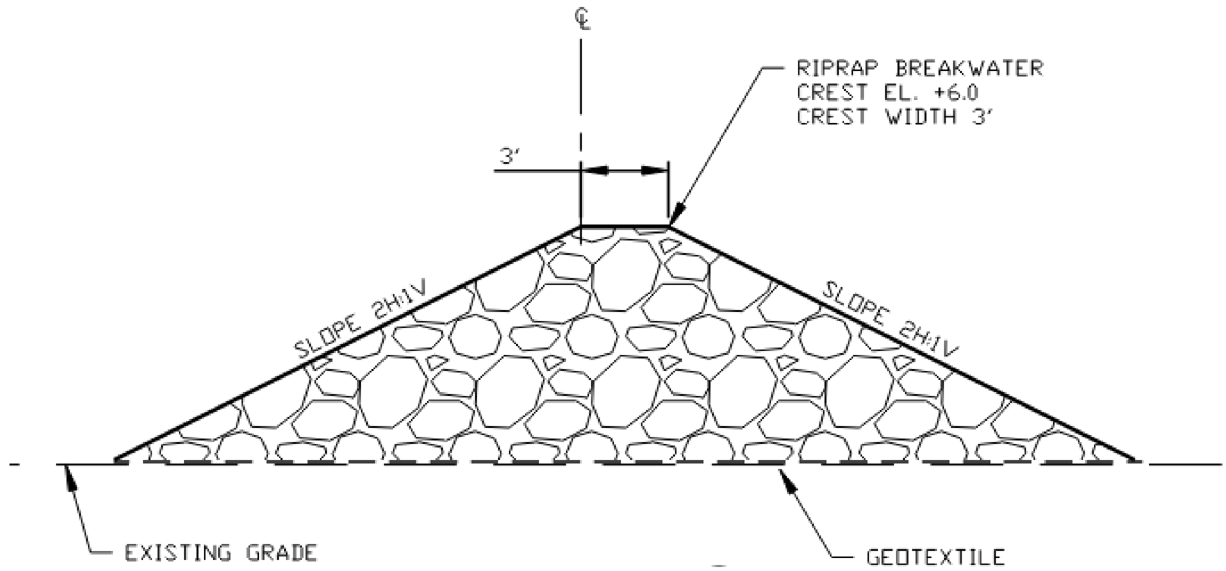


Figure 6: Design Breakwater Cross-Section for Permitting

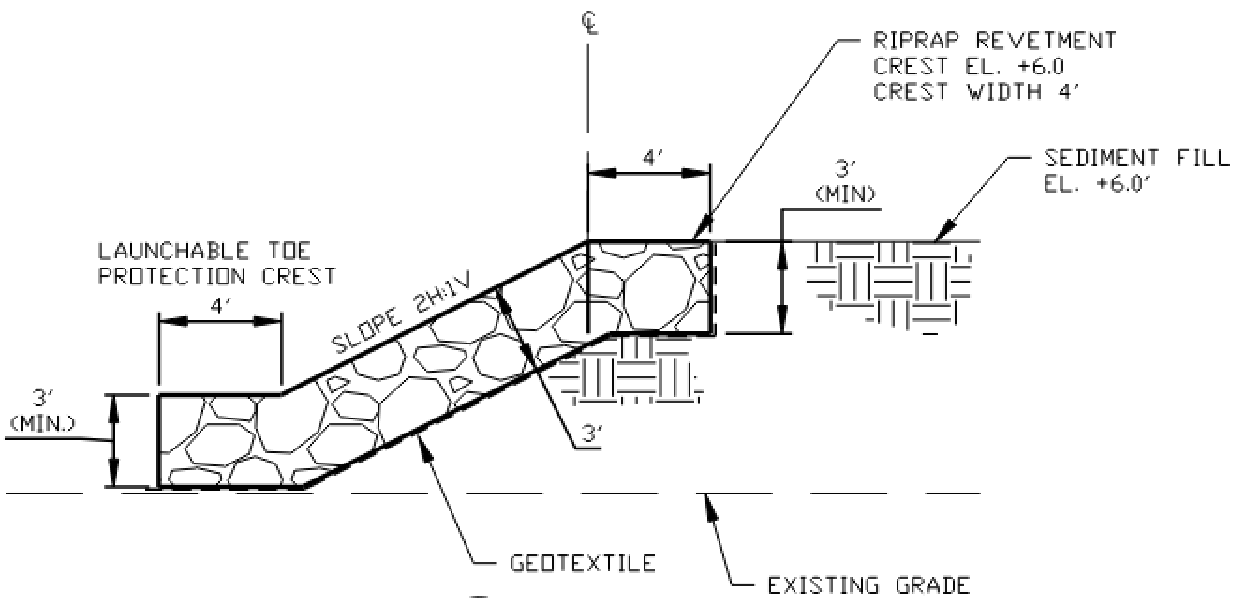


Figure 7: Design Revetment Cross-Section for Permitting

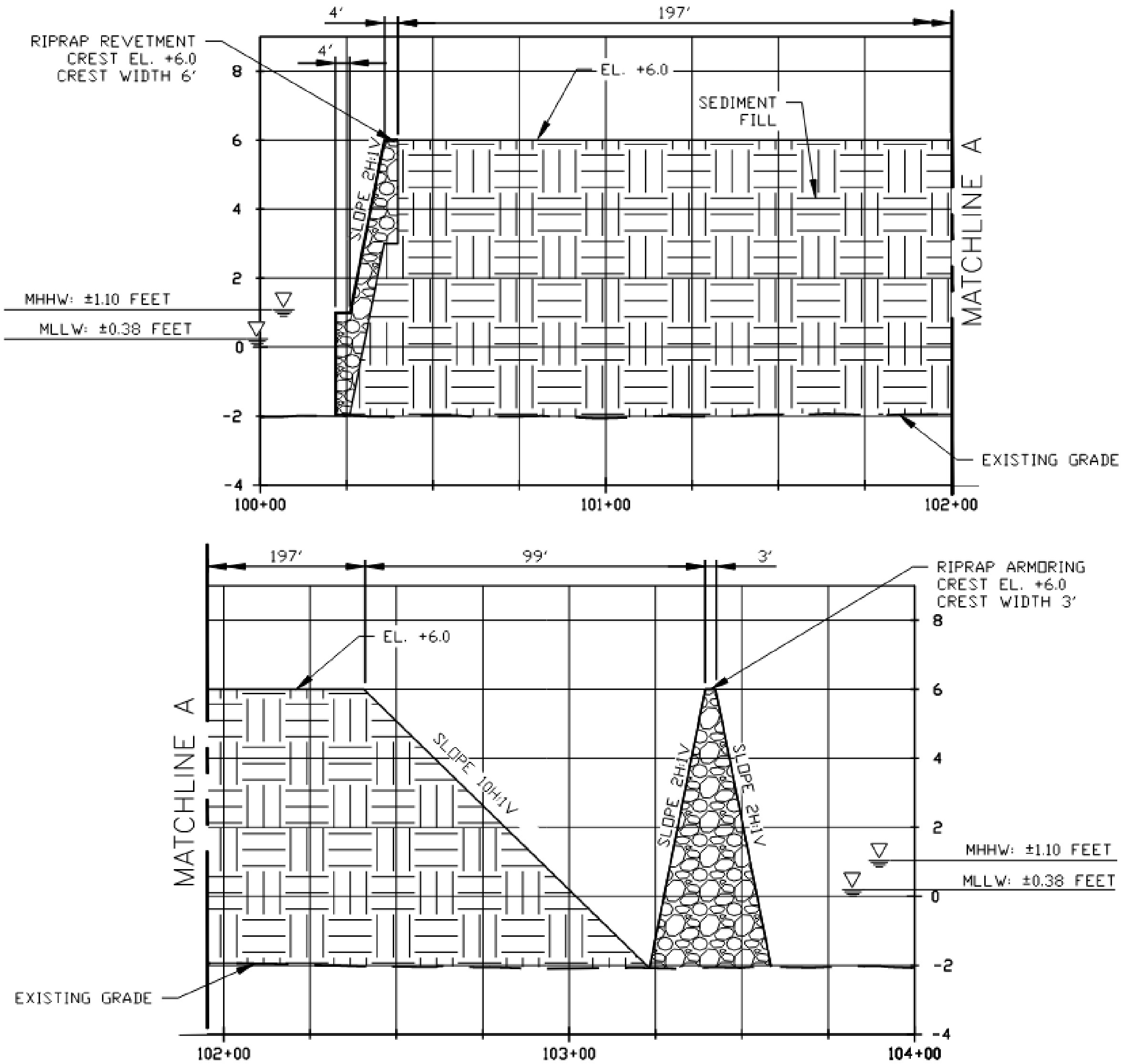


Figure 8: Rookery Island Cross-Section

2.10 COST ESTIMATE AND CONSTRUCTABILITY

The opinion of probable construction costs is shown in Table 12 and is based on updated estimates from similar coastal restoration projects based in Louisiana and Texas over the past three to five years. The assumptions include 15% for Mobilization/Demobilization, 6% for Stabilized Construction Access and Laydown, Geotechnical is approximately 1.5%, and Construction Survey is approximately 2.7%. Mobilization/Demobilization is assumed to account for getting all equipment to the project site, assembling the equipment, setting up the dredge pipeline and preparing to pump dredge sediment. Stabilized Construction Access and Laydown is assumed to include considerations for renting a nearby upland area to transload material as necessary or stage equipment nearby. There is no specified laydown area near the project site as this area is known to be private land and permission will likely not be granted. However, it is typical for on-water construction to utilize barges to stage materials and equipment and utilize a nearby dock to stage materials and transfer to barges.

Two towns with boat launches and facilities with marine access are located nearby. Either could be used by a contractor if necessary. They include Palacios, Texas located approximately 10 miles East of the project and Port Lavaca, Texas located approximately 20 miles West of the project. Geotechnical Investigation accounts for the contractor collecting sediment cores or samples to confirm design assumptions, as necessary. The pre and post construction surveys account for surveys to define pre and as-built project conditions. This assumes the surveys shall be completed, processed, and plotted for review by the client and engineer of record for approval. Interim surveys are anticipated, but these are assumed to be completed by the contractor for their own verification. The project is estimated to cost approximately $4.0 million.

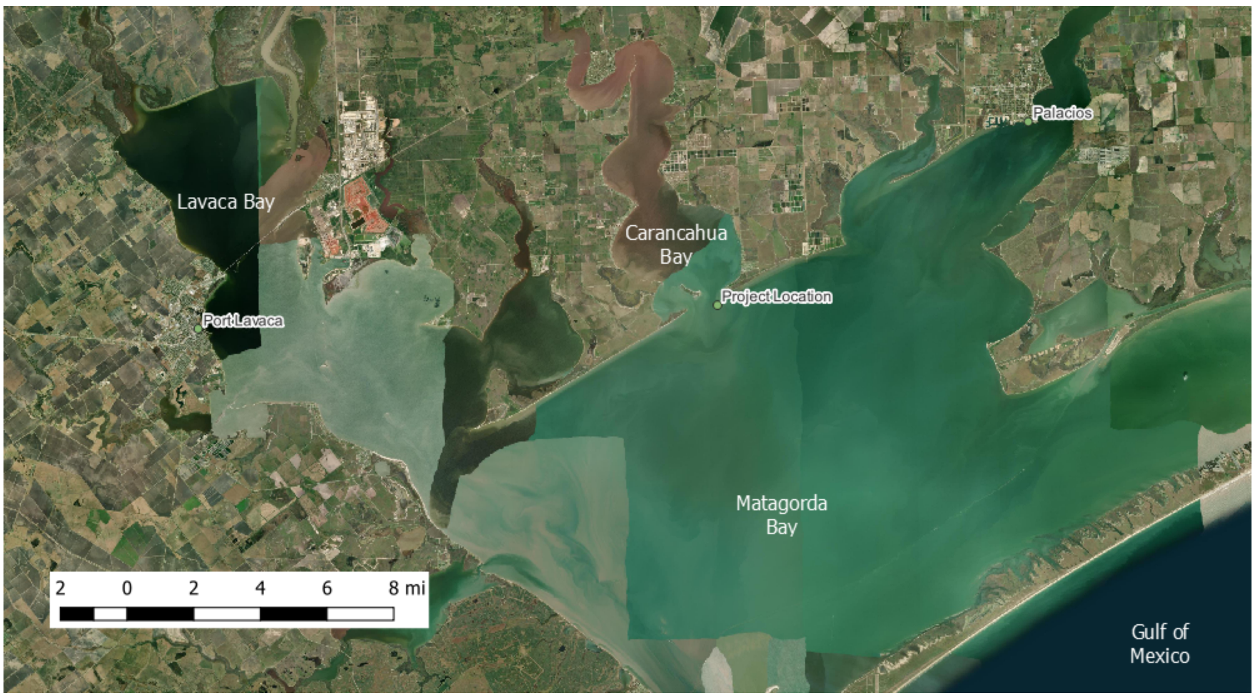


Figure 9: Project Area and Potential Construction Access Points

Table 12: Opinion of Probable Construction Costs

Innovative approaches
Practical results
Outstanding service

OPINION OF PROBABLE CONSTRUCTION COST

PROJECT NAME	Carancahua Bay Mouth Rookery Island Design	DATE	6/6/2023
CLIENT	Audubon Texas	GROUP	1169
% SUBMITTAL	Feasibility Study	PM	Matt Salmon

ESTIMATED BY	QC CHECKED BY	FNI PROJECT NUMBER
Matt Salmon	Carl Sepulveda / John Rinacke	ADB22691

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
SITE PREPARATION					
1	Mobilization/Demobilization	1	LS	$ 410,000.00	$ 410,000
2	Stabilized Construction Access and Laydown Area	1	LS	$ 184,000.00	$ 184,000
3	Geotechnical Investigation	1	LS	$ 40,000.00	$ 40,000
4	Pre-, two interim, and Post-Construction Survey	1	LS	$ 150,000.00	$ 150,000
5	Aerial Photography	1	LS	$ 20,000.00	$ 20,000
ISLAND CONSTRUCTION					
6	Rip-Rap Armor Erosion Protection	6,500	TONS	$ 120.00	$ 780,000
7	Sand/Shell-Hash Island Fill	29,900	CY	$ 45.00	$ 1,345,500
8	Geotextile filter-fabric for rip-rap armor	38,900	SF	$ 5.00	$ 194,500
9	Navigation Aids	1	LS	$ 20,000.00	$ 20,000
		SUBTOTAL			$ 3,144,000
		CONTINGENCY		20%	$ 628,800
		SUBTOTAL			$ 3,772,800
		Const. Mang. / Const. Insp.			$ 205,000
		SUBTOTAL			$ 3,977,800
		Monitoring			$ 30,000
PROJECT TOTAL (2023 COSTS)					**$ 4,007,800**

The Engineer has no control over the cost of labor, materials, equipment, or over the Contractor's methods of determining prices or over competitive bidding or market conditions. Opinions of probable costs provided herein are based on the information known to Engineer at this time and represent only the Engineer's judgment as a design professional familiar with the construction industry. The Engineer cannot and does not guarantee that proposals, bids, or actual construction costs will not vary from its opinions of probable costs.

2.11 PERMITTING

The draft Nationwide Permit 27 (NWP 27): Aquatic Habitat Restoration, Enhancement, and Establishment Activities Pre-construction Notification (PCN) application for the construction of a rookery island with a total overall footprint of 2.7 acres at the mouth of Carancahua Bay was submitted to Audubon Texas (Alexis Baldera) on February 23, 2023, for review and signature. The final compiled permit application was submitted to the U.S. Army Corp of Engineers (USACE): Galveston District for evaluation on March 1, 2023.

The Carancahua Bay Mouth Rookery Island project permit application was assigned to Ms. Kayla Roberts as the USACE District Engineer on March 6, 2023. The USACE has reviewed the permit application and determined that the permit area was likely to yield archeological sites. On March 22, 2023, the USACE recommended that a marine archeological survey be performed to assess the presence of artifacts within the project area.

Audubon and FNI reached out to Bob Hydrographics, LLC. for a proposal for a marine archeological survey with magnetometer and sonar data, as requested by USACE. Because of the nature of the CMP grant, Audubon is not authorized to begin marine surveys until specific marine survey plans and methodologies are submitted to satisfy the requirements of NEPA. Audubon is currently awaiting approval from NOAA to proceed with the marine archeological survey.

REFERENCES

ASCE 2022. ASCE 7 Hazard Tool Online. Website accessed on December 28, 2022. https://asce7hazardtool.online.

CERC 1973. Coastal Engineering Research Center (US). *Shore protection manual*. Vol. 1. US Army Coastal Engineering Research Center, 1973.

CIARA 2007. The Rock Manual – The use of rock in hydraulic engineering (2nd edition). CIRIA C683.

FEMA 2018. Federal Emergency Management Agency Flood Insurance Study Number 48057CV001B. Calhoun County, Texas and Incorporated Areas Volume 1 of 3.

FNI 2020. Feasibility Report: Carancahua Bay Mouth Bird Island. Prepared for Audubon Texas on July 29, 2020.

GLO 2023. Texas Sediment Geodatabase. Accessed February 7, 2023. https://cgis.glo.texas.gov/txsed/index.html.

Leenknecht 1992. Leenknecht, David A., Andre Szuwalski, and Ann R. Sherlock. *Automated coastal engineering system: User's guide*. ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG MS, 1992.

NDBC 2022. NOAA National Data Buoy Center Station PTAT2 Port Aransas, Texas. Website accessed on 12/22/2022. url: https://www.ndbc.noaa.gov/station_page.php?station=PTAT2

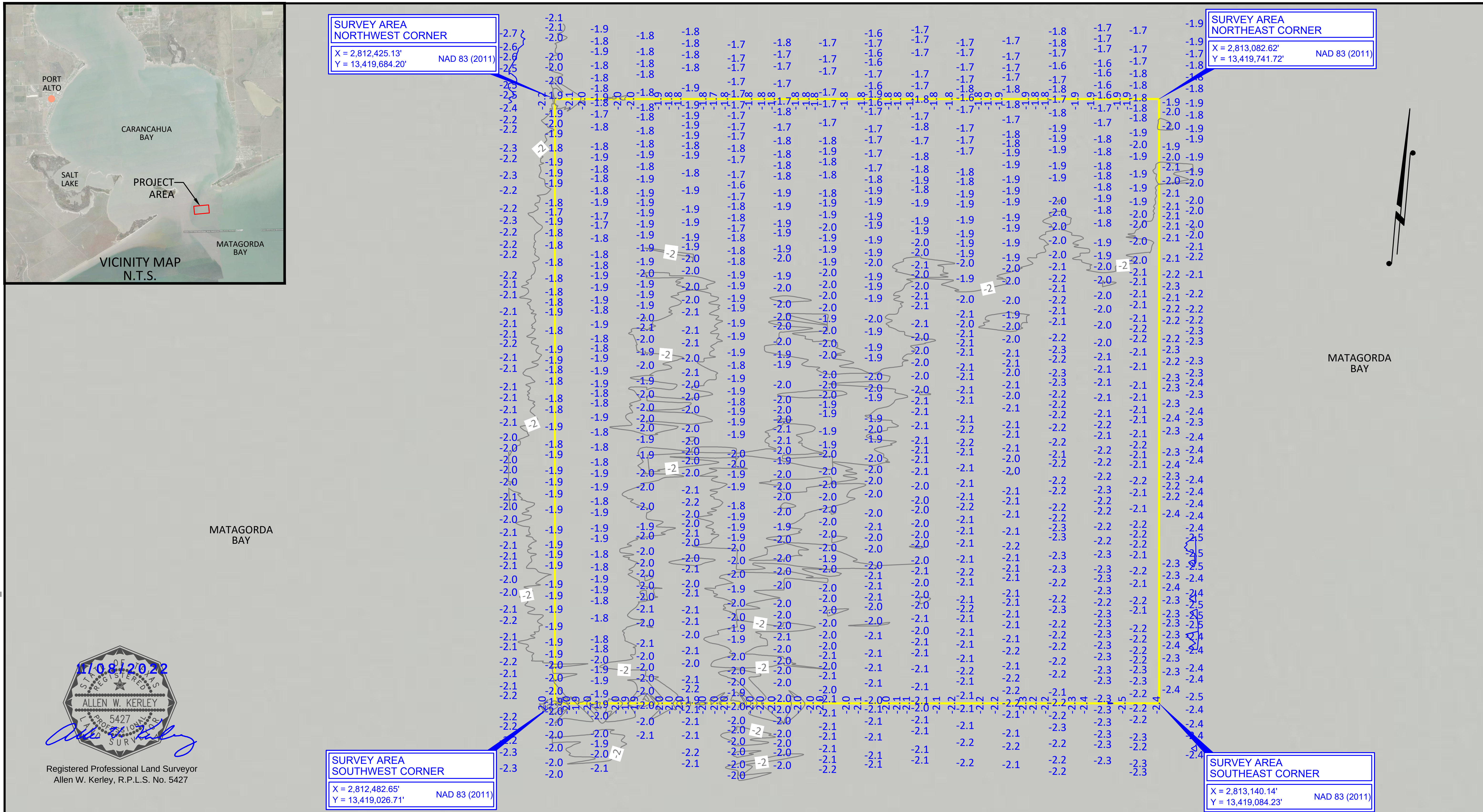
NOAA 2022. NOAA Tides and Currents – Datums for 8773701, Port O'Connor TX gage. Website accessed on 12/22/2022. url: https://tidesandcurrents.noaa.gov/datums.html?datum=NAVD88&units=0&epoch=0&id=8773701&name=Port+O%27Connor&state=TX.

NOAA 2023. Sea Level Rise Viewer. Website accessed on 1/3/2023. https://coast.noaa.gov/slr/

SciPy 2020. Pauli Virtanen, Ralf Gommers, Travis E. Oliphant, Matt Haberland, Tyler Reddy, David Cournapeau, Evgeni Burovski, Pearu Peterson, Warren Weckesser, Jonathan Bright, Stéfan J. van der Walt, Matthew Brett, Joshua Wilson, K. Jarrod Millman, Nikolay Mayorov, Andrew R. J. Nelson, Eric Jones, Robert Kern, Eric Larson, CJ Carey, İlhan Polat, Yu Feng, Eric W. Moore, Jake VanderPlas, Denis Laxalde, Josef Perktold, Robert Cimrman, Ian Henriksen, E.A. Quintero, Charles R Harris, Anne M. Archibald, Antônio H. Ribeiro, Fabian Pedregosa, Paul van Mulbregt, and SciPy 1.0 Contributors. (2020) **SciPy 1.0: Fundamental Algorithms for Scientific Computing in Python.** *Nature Methods*, 17(3), 261-272.

USACE 2007. "US Army Corps of Engineers, Coastal Engineering Manual (CEM), Engineer Manual 1110-2-1100. US Army Corps of Engineers, Washington, DC (6 volumes).

APPENDIX A
Bathymetric Survey



Registered Professional Land Surveyor
Allen W. Kerley, R.P.L.S. No. 5427

11/8/2022 - P:\Y-2022\2022.1108\DWG\FREESE - BIRD ISLAND BATHY SURVEY_7NOV2022.DWG

NOTES:

1. SOUNDINGS WERE RECORDED BY T. BAKER SMITH ON 7 NOVEMBER, 2022. SEA FLOOR CONDITIONS ARE SUBJECT TO CHANGE.
2. HORIZONTAL DATUM: NAD83 (2011), TEXAS SOUTH CENTRAL ZONE. ALL DISTANCES ARE U.S. SURVEY FEET (GRID).
3. VERTICAL: NAVD88 (GEOID 18)

"CAMPO RM 1 "
N: 13,433,535.1'
E: 2,815,309.2'
ELEV: 4.4' NAVD88

T. BAKER SMITH
A CENTURY OF SOLUTIONS
3854 FM 1069
Aransas Pass, TX 78336
(361)334-5719 - tbsmith.com
TBPLS #10194575

SCALE: 1" = 100'

100' 50' 0' 100'

REV. NO: 00	REV. DATE: --/--/--	REV. BY: ---

REVISION DESCRIPTION:
--

DRAWN BY: CDW	APPROVED BY: AKW
DATE: 11/08/2022	JOB NO: 2022.1108

DRAWING NAME:
FREESE - BIRD ISLAND BATHY SURVEY_7NOV2022

PROJECTION: TEXAS STATE PLANE SOUTH CENTRAL
GEO. DATUM: NAD83 (2011) | VERT. DATUM: NAVD88
GRID UNITS: US SURVEY FEET

SHEET NO: 1 OF 1

BATHYMETRIC SURVEY

FREESE & NICHOLS, INC.
CARANCAHUA PASS BIRD ISLAND
AN EXHIBIT OF A
BATHYMETRIC SURVEY
LOCATED IN
MATAGORDA COUNTY, TEXAS

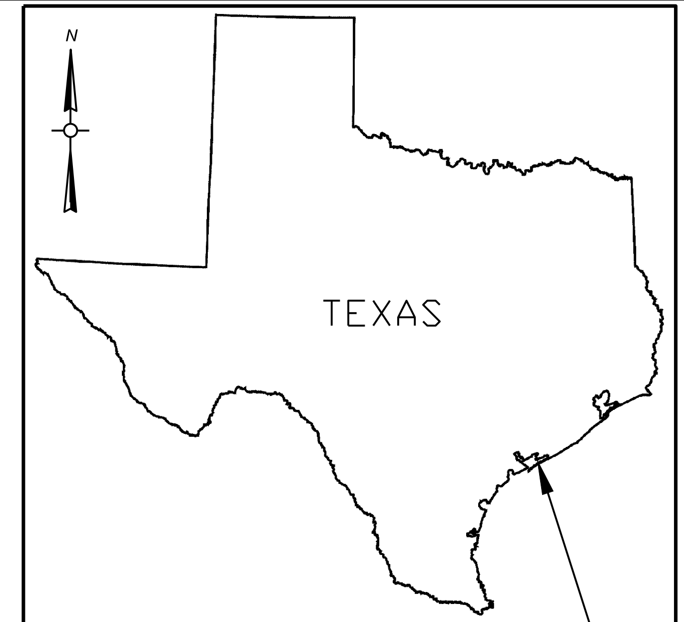
APPENDIX B
90% Design Plan Set

CARANCAHUA BAY MOUTH ROOKERY ISLAND

CALHOUN COUNTY, TEXAS

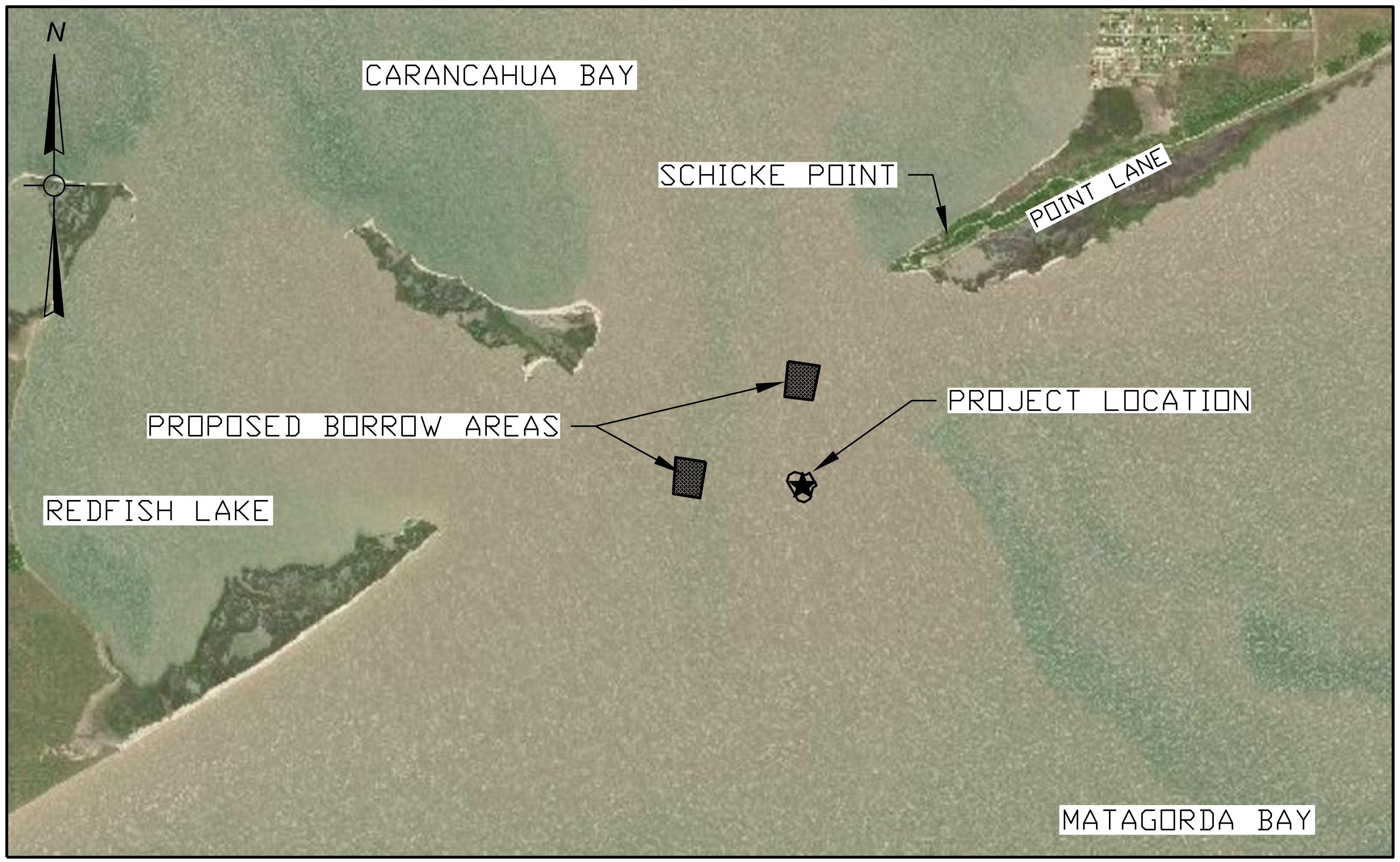
INDEX OF SHEETS

SHT NO.	SHEET NAME
1	COVER SHEET
2	GENERAL NOTES
3	OVERALL SITE PLAN
4	PLAN VIEW
5	BORROW AREA TYPICAL SECTIONS
6	ISLAND TYPICAL SECTION
7	REVETMENT AND BREAKWATER TYPICAL SECTIONS
8	BORROW AREA LAYOUT
9-11	REVETMENT AND BREAKWATER CROSS SECTIONS
12-14	ISLAND CROSS SECTIONS
15-22	BORROW AREA CROSS SECTIONS



VICINITY MAP

PROJECT LOCATION



2000' 0 2000' 4000'

SCALE: 1"=2000'

Prepared for: Audubon Texas
Prepared by: Freese and Nichols, Inc. - Texas
Texas Registered Engineering Firm F-2144
AIMS Group Inc.

90% SUBMITTAL

THIS DOCUMENT IS RELEASED FOR THE PURPOSE OF INTERIM REVIEW UNDER THE AUTHORITY OF: MATT SALMON P.E. TEXAS NO: 143709 ON DATE: 6/01/2023 IT IS NOT TO BE USED FOR CONSTRUCTION, BIDDING OR PERMIT PURPOSES.

Freese and Nichols, Inc.
Texas Registered Engineering Firm F-2144

F&N JOB NO. ADB20155
DATE 6/01/2023
SCALE
DESIGNED MLS
DRAFTED RH
FILE 1 Cover.dwg

AUDUBON TEXAS
CARANCAHUA BAY MOUTH ROOKERY ISLAND
COVER SHEET

FREESE NICHOLS
10431 Morado Circle, Suite 300
Austin, Texas 78759
Phone - (512) 617-3100
Web - www.freese.com

Audubon

1
SHEET

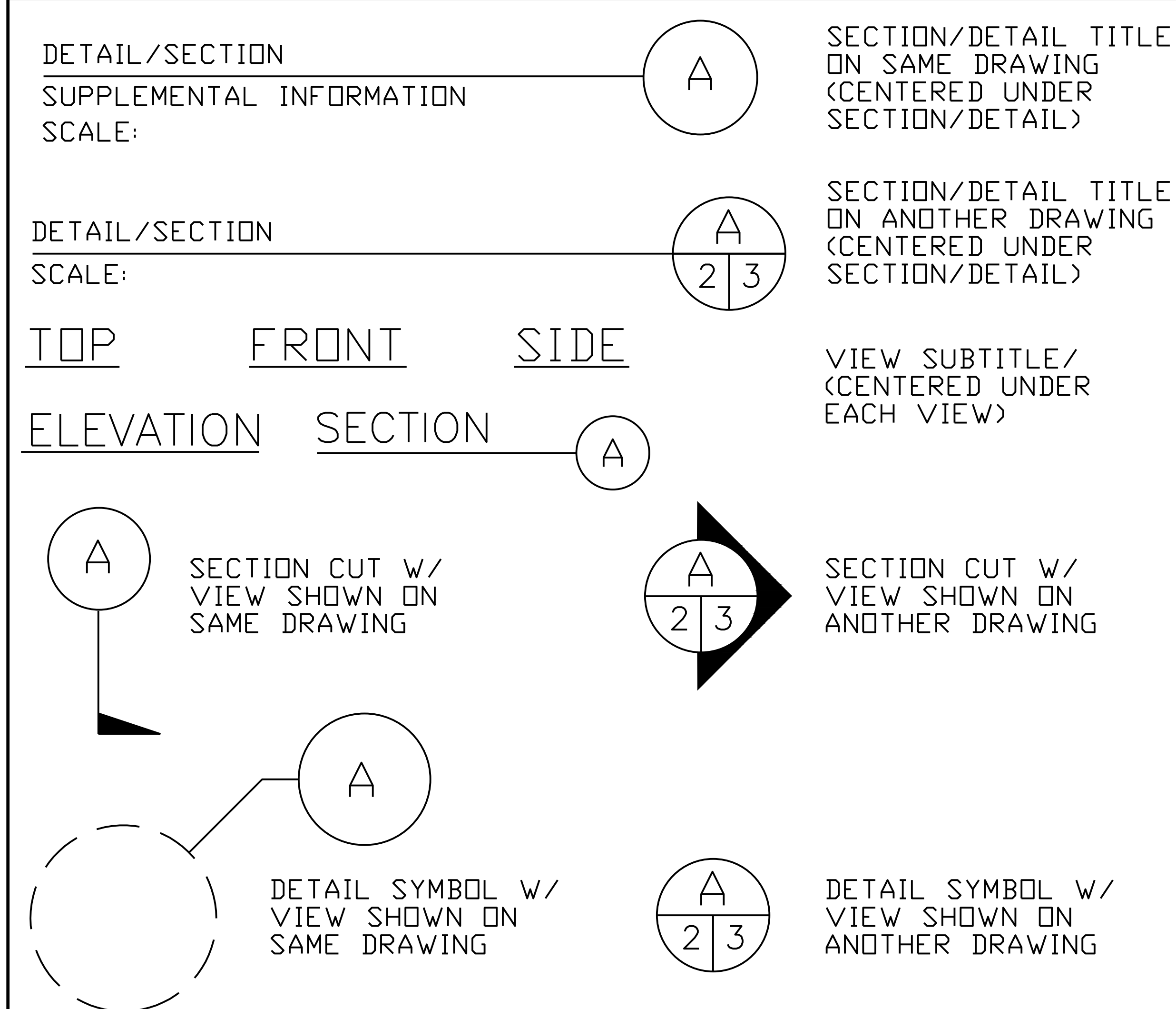
ACAD Rel: 24.1s (LMS Tech)
Filename: H:\WR_DESIGN\CAD\2023-06-01 - 90% Submittal REV1 - Drawings Cad Files\1 Cover.dwg
Last Saved: 6/7/2023 8:39 AM Saved By: 03775

Plot Date: 6/7/2023 8:41 AM Plot By: 03775 Filename: H:\WR_DESIGN\CAD\2023-06-01 - 90% Submittal REV1 - Drawings Cad Files\1 Cover.dwg

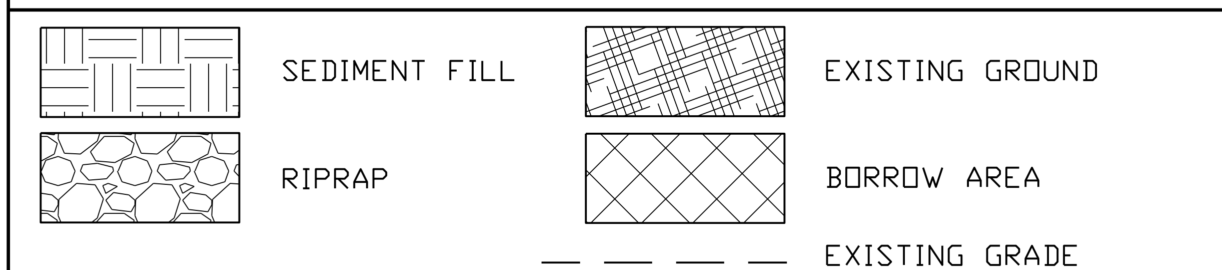
GENERAL NOTES:

1. ALL ELEVATIONS SHOWN IN FEET REFERENCED TO NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88).
2. HORIZONTAL COORDINATES SHOWN ARE REFERENCED TO STATE PLANE TEXAS SOUTH CENTRAL ZONE 5401, U.S. SURVEY FEET.
3. ALL ELEVATIONS SHOWN IN FEET REFERENCED TO NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88). ALL HORIZONTAL COORDINATES ARE REFERENCED TO THE NORTH AMERICAN DATUM OF 1983 (NAD83), TEXAS STATE PLANE, SOUTH CENTRAL ZONE, IN FEET.
4. AERIAL PHOTOGRAPHS FROM ESRI DECEMBER 2018.
5. PROJECT SITE IS NOT ACCESSIBLE BY LAND. CONTRACTOR SHALL BE RESPONSIBLE FOR ACCESSING THE SITE FROM A NAVIGABLE WATERBODY.
6. DREDGING FOR SITE ACCESS IS NOT PERMITTED.
7. TOPOGRAPHIC AND BATHYMETRIC DATA FOR THE ISLAND FOOTPRINT COMPLETED BY T BAKER SMITH ON NOVEMBER 7, 2022. THE BORROW AREAS ARE BASED ON NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION CONTINUALLY UPDATED COASTAL DIGITAL ELEVATION MODEL 2021. CONTRACTOR TO CONFIRM ALL ELEVATIONS.
8. CONTRACTOR SHALL PERFORM A PRE-CONSTRUCTION HAZARD (MAGNETOMETER) SURVEY AND LOCATE ALL UTILITIES AND OBSTRUCTIONS PRIOR TO COMMENCING WORK.
9. EXISTING UTILITIES SHOWN ARE APPROXIMATE. CONTRACTOR SHALL BE RESPONSIBLE FOR NOTIFYING PIPELINE/UTILITY OPERATORS AND TEXAS ONE CALL (1-800-545-6005) 10 WORKING DAYS PRIOR TO MOBILIZATION. ALL PIPELINES AND UNDERGROUND UTILITIES SHALL BE MARKED BY CONTRACTOR. CONTRACTOR SHALL MAINTAIN MARKERS DURING CONSTRUCTION. IT IS CONTRACTOR'S RESPONSIBILITY TO MAINTAIN CLEARANCES SET FORTH IN THE PLANS AND BID DOCUMENTS. NO EXCAVATION IS ALLOWED WITHIN ANY AREA RESTRICTED BY PIPELINE/UTILITY COMPANIES.
10. PROJECT IS WITHIN AND ADJACENT TO ENVIRONMENTALLY SENSITIVE AREAS. CONTRACTOR SHALL AVOID/MINIMIZE IMPACTS TO THESE AREAS DURING THE COURSE OF WORK. TO HELP AVOID/MINIMIZE IMPACTS, HEAVY EQUIPMENT SHALL NOT BE OPERATED FROM LAND. OWNER RESERVES THE RIGHT TO SUSPEND WORK AT ANY TIME IF IMPACTS OCCUR UNTIL SATISFACTORY CORRECTIVE MEASURES ARE IMPLEMENTED BY CONTRACTOR. REFER TO THE SPECIAL PROVISIONS AND SPECIFICATION SECTION [DEFINE SECTION IN FUTURE PHASE WHEN SPECS ARE DEVELOPED] FOR ADDITIONAL REQUIREMENTS, INCLUDING CONDITIONS TO AVOID IMPACTS TO SEA TURTLES.
11. CONTRACTOR SHALL BE FAMILIAR WITH AND ANTICIPATE EXISTING SOIL CONDITIONS AT THE WORK SITE BASED ON THE SOIL INVESTIGATION DATA ACQUIRED BY [INSERT FUTURE GEOTECH FIRM] AND PRESENTED IN [INSERT REPORT APPENDIX WITH BORINGS].
12. LOCATIONS OF CULTURAL RESOURCE AREAS ARE BASED ON [DEFINE REPORT IN [FUTURE PHASE]. CONTRACTOR SHALL NOT DISTURB CULTURAL RESOURCE AREAS.
13. CONTRACTOR SHALL TAKE PRECAUTIONS, SECURE EQUIPMENT, AND PROTECT THE WORK AGAINST ADVERSE WEATHER, MARINE CONDITIONS, AND/OR SURGE/WAKE FROM PASSING VESSELS.
14. THE INTENT OF THE PROJECT ALIGNMENT IS TO ADEQUATELY PLACE ARMOR MATERIAL TO PROTECT THE SHORE. CONTRACTOR SHALL OBTAIN WRITTEN NOTICE/CONCURRENCE FROM ENGINEER PRIOR TO ALL ALIGNMENT CHANGES.
15. PERMANENT NAVIGATION AIDS TO BE LOCATED ALONG THE STRUCTURE IN ACCORDANCE WITH U.S. COAST GUARD REGULATIONS.

GENERAL CROSS-REFERENCING SYMBOLS



LEGEND



ACRONYMS:

MHHW: MEAN HIGHER HIGH WATER
MLLW: MEAN LOWER LOW WATER
NAVD88: NORTH AMERICAN VERTICAL DATUM OF 1988

ITEM	QTY	UNITS
RIPRAP EROSION PROTECTION	6,425	TONS
SAND/SHELL-HASH ISLAND FILL	22,950	CY
GEOTEXTILE FILTER-FABRIC FOR RIPRAP ARMOR	90,480	SF
BORROW AREA A VOLUME	31,100	CY
BORROW AREA B VOLUME	27,000	CY

90% SUBMITTAL
THIS DOCUMENT IS RELEASED FOR THE PURPOSE OF INTERIM REVIEW UNDER THE AUTHORITY OF: MATT SALMON P.E. TEXAS NO: 143709 ON DATE: 6/01/2023 IT IS NOT TO BE USED FOR CONSTRUCTION, BIDDING OR PERMIT PURPOSES.

Freese and Nichols, Inc.
Texas Registered Engineering Firm F-2144

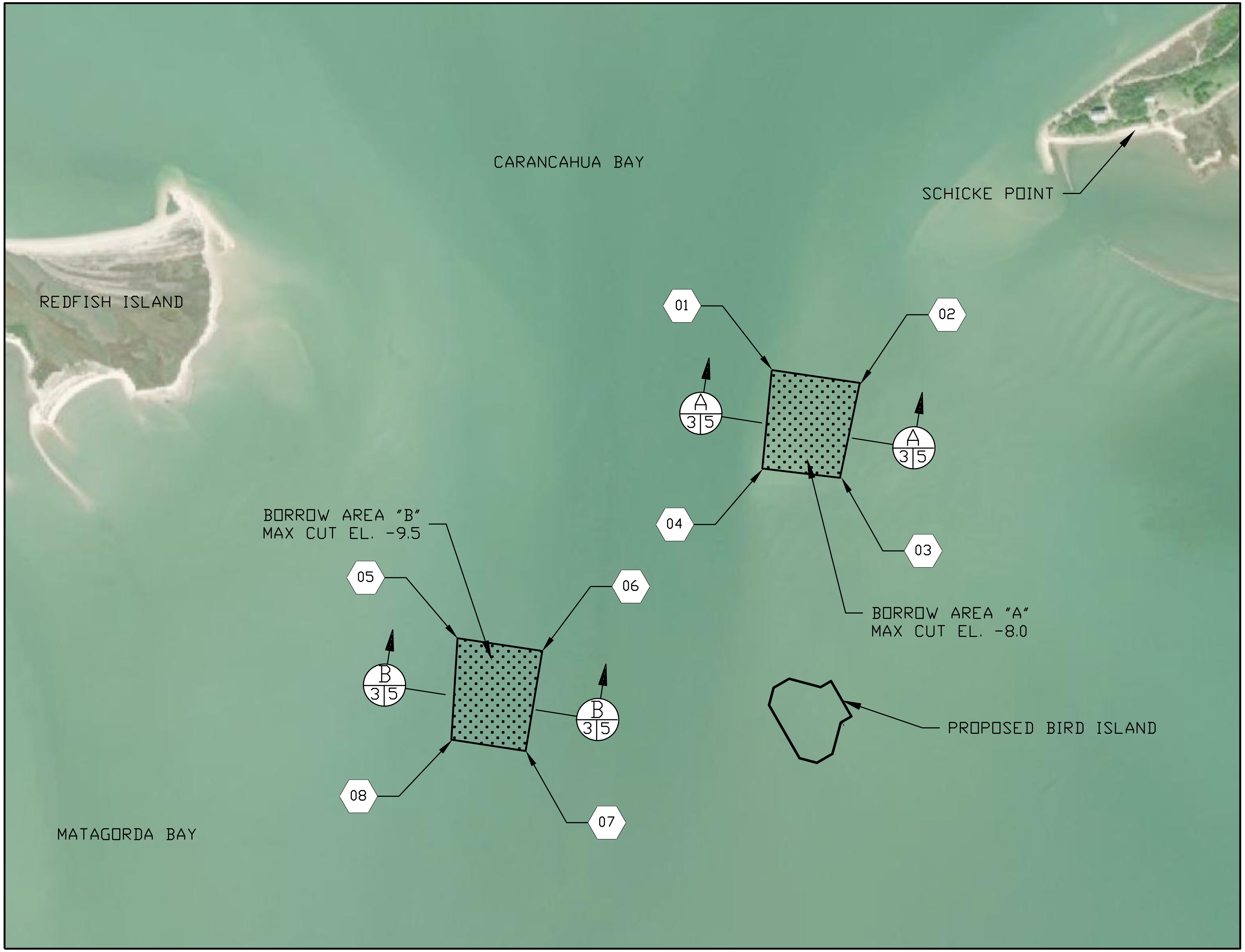
AUDUBON TEXAS
CARANCAHUA BAY MOUTH ROOKERY ISLAND
GENERAL NOTES

F&N JOB NO. ADB20155
DATE 6/01/2023
SCALE
DESIGNED MLS
DRAFTED RH
FILE 2 General Notes.dwg

FREESE NICHOLS
10431 Morado Circle, Suite 300
Austin, Texas 78759
Phone - (512) 617-3100
Web - www.freese.com

SHEET 2

ACAD Rel: 23.0s (LMS Tech)
Filename: M:\A22-029 FNI-Bird Island (Texas)\CAD\2 General Notes.dwg
Last Saved: 6/1/2023 11:02 AM Saved By: Robin



OVERALL SITE PLAN

500' 0 500' 1000'

SCALE: 1"=500'

N

BORROW AREA A		
NO.	NORTHING	EASTING
01	13,420,975.34	2,812,597.44
02	13,420,915.55	2,813,004.04
03	13,420,476.82	2,812,912.46
04	13,420,519.70	2,812,553.82

BORROW AREA B		
NO.	NORTHING	EASTING
05	13,419,735.39	2,811,145.35
06	13,419,676.20	2,811,537.11
07	13,419,213.61	2,811,459.82
08	13,419,266.04	2,811,117.21

90% SUBMITTAL

THIS DOCUMENT IS RELEASED FOR THE PURPOSE OF INTERIM REVIEW UNDER THE AUTHORITY OF: MATT SALMON P.E. TEXAS NO: 143709 ON DATE: 6/01/2023 IT IS NOT TO BE USED FOR CONSTRUCTION, BIDDING OR PERMIT PURPOSES.

Freese and Nichols, Inc.
Texas Registered Engineering Firm F-2144

F&N JOB NO. ADB20155
DATE 6/01/2023
SCALE
DESIGNED MLS
DRAFTED RH
FILE 3 Overall Plan.dwg

AUDUBON TEXAS

CARANCAHUA BAY MOUTH ROOKERY ISLAND

OVERALL SITE PLAN

FREESE NICHOLS
10431 Morado Circle, Suite 300
Austin, Texas 78759
Phone - (512) 617-3100
Web - www.freese.com

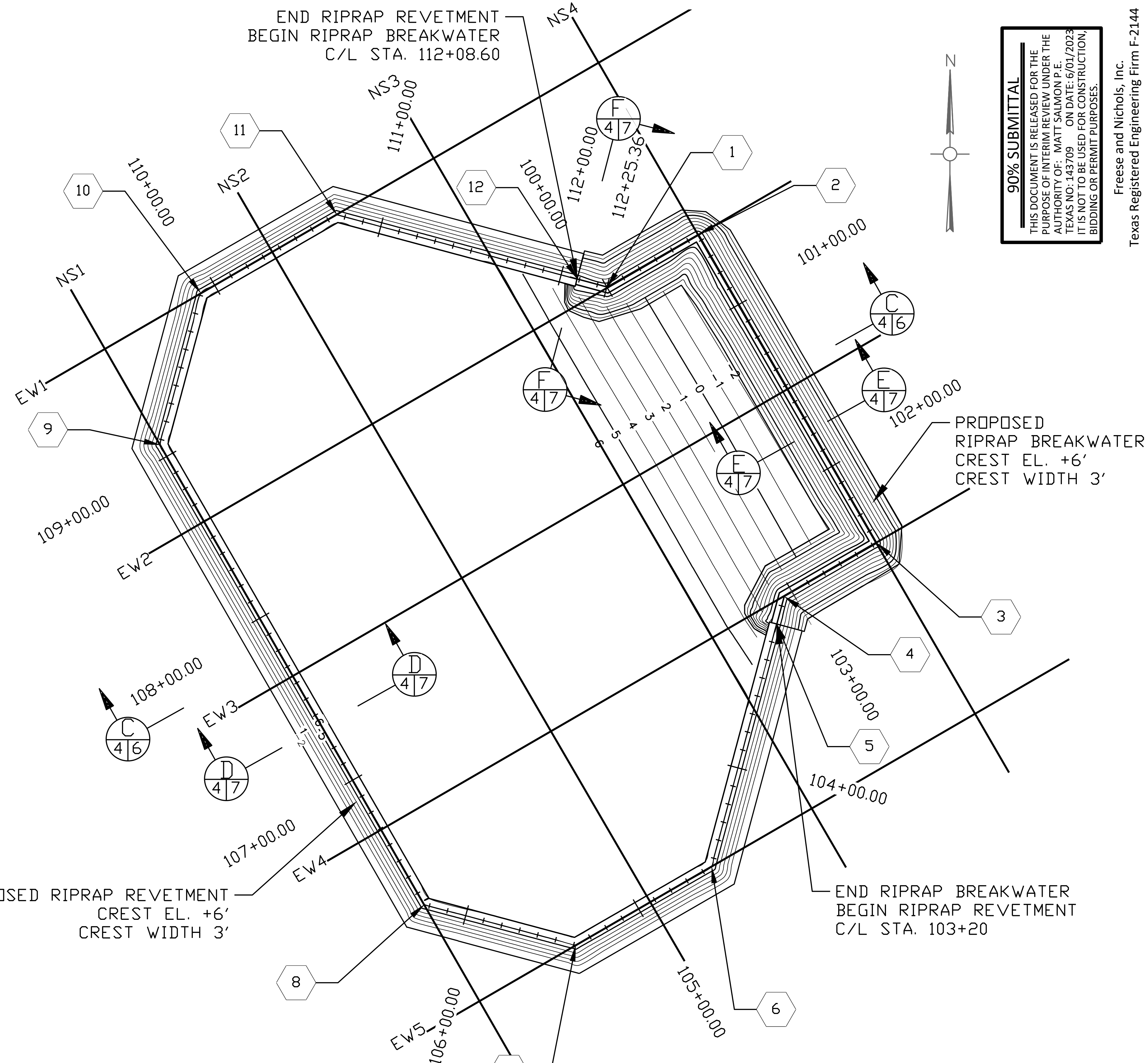
ACAD Rel: 23.0s (LMS Tech)
Filename: M:\A22-029 FNI-Bird Island (Texas)\CAD\3 Overall Plan.dwg
Last Saved: 5/16/2023 12:36 PM Saved By: Robin

Plot Date: 6/1/2023 11:32 AM Plot By: Robin Filename: M:\A22-029 FNI-Bird Island (Texas)\CAD\3 Overall Plan.dwg

BIRD ISLAND SURVEY TRANSECTS				
NO.	BEGIN NORTHING	BEGIN EASTING	END NORTHING	END EASTING
EW1	13,419,485.44	2,812,527.26	13,419,686.18	2,812,873.25
EW2	13,419,393.24	2,812,580.81	13,419,593.98	2,812,926.79
EW3	13,419,310.74	2,812,628.80	13,419,511.48	2,812,974.78
EW4	13,419,228.59	2,812,676.48	13,419,403.56	2,813,016.31
EW5	13,419,137.07	2,812,729.72	13,419,337.82	2,813,075.70
NS1	13,419,535.95	2,812,540.94	13,419,122.95	2,812,778.02
NS2	13,419,587.91	2,812,630.33	13,419,175.97	2,812,869.69
NS3	13,419,638.15	2,812,716.79	13,419,226.21	2,812,956.15
NS4	13,419,689.45	2,812,805.09	13,419,277.07	2,813,043.44

BIRD ISLAND CENTERLINE TABULATIONS			
NO.	STATION	NORTHING	EASTING
1	BEGIN:100+00 END:112+25.36	13,419,510.38	2,812,822.56
2	100+56.47	13,419,538.60	2,812,871.52
3	102+47.45	13,419,373.21	2,812,966.99
4	103+04.71	13,419,344.56	2,812,917.41
5	103+20	13,419,329.81	2,812,913.46
6	104+54.71	13.419.199.67	2.812.878.59
7	105+38.85	13.419.157.60	2.812.805.72
8	106+22.87	13.419.179.34	2.812.724.56
9	109+07.02	13.419.425.77	2.812.583.11
10	109+91.27	13,419,507.16	2,812,604.92
11	110+75.40	13.419.549.22	2.812.677.77
12	112+08.60	13,419,514.72	2,812,806.45

NOTES:
1. CENTERLINE TABULATIONS TAKEN FROM EXTERIOR EDGE AT THE TOP OF RIPRAP BREAKWATER AND EXTERIOR EDGE AT THE TOP OF THE RIPRAP REVETMENT.
2. SEE SHEETS 9-14 FOR CROSS SECTIONS.



PLAN VIEW

60' 0 60' 120'

SCALE: 1"=60'

90% SUBMITTAL

THIS DOCUMENT IS RELEASED FOR THE PURPOSE OF INTERIM REVIEW UNDER THE AUTHORITY OF: MATT SALMON P.E. TEXAS NO: 143709 ON DATE: 6/01/2023 IT IS NOT TO BE USED FOR CONSTRUCTION, BIDDING OR PERMIT PURPOSES.

Freese and Nichols, Inc.
Texas Registered Engineering Firm F-2144

AUDUBON TEXAS

CARANCAHUA BAY MOUTH ROOKERY ISLAND

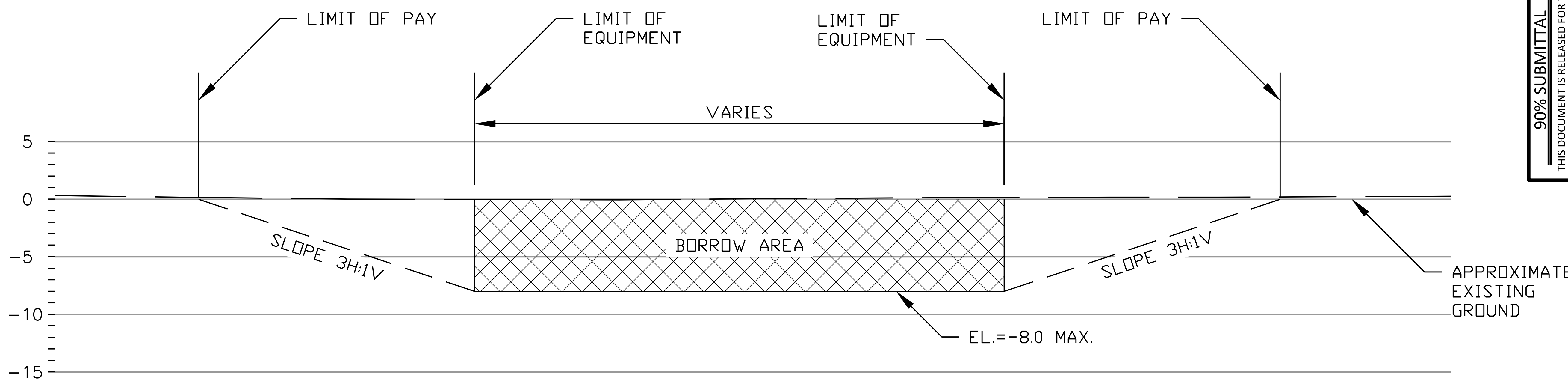
PLAN VIEW

F&N JOB NO. ADB20155
DATE 6/01/2023
SCALE
DESIGNED MLS
DRAFTED RH
FILE 4 Plan View.dwg

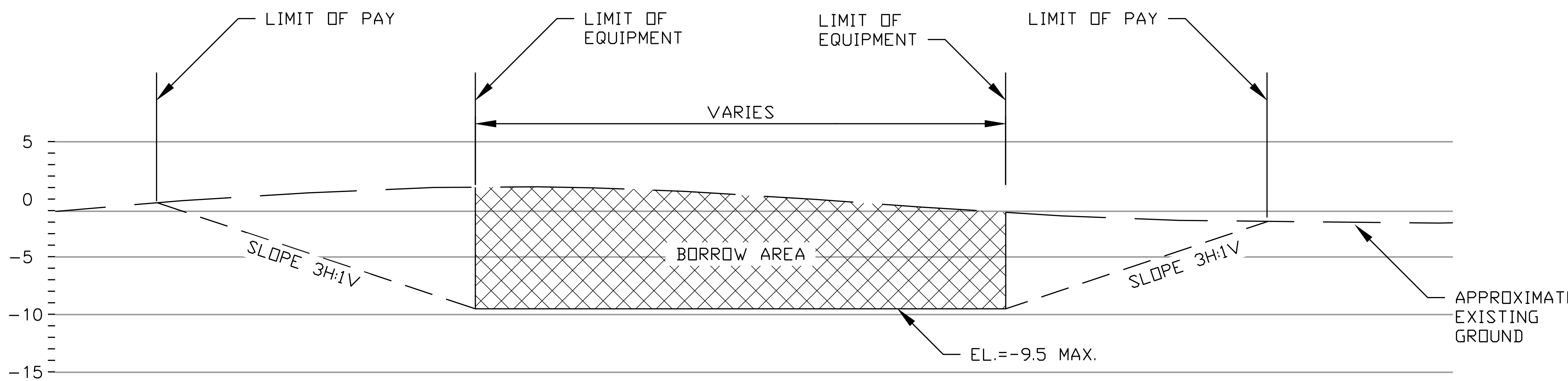
FREESE NICHOLS
10431 Morado Circle, Suite 300
Austin, Texas 78759
Phone - (512) 617-3100
Web - www.freese.com

4
SHEET

ACAD Rel: 23.0s (LMS Tech)
Filename: M:\A22-029 FNI-Bird Island (Texas)\CAD\4 Plan View.dwg
Last Saved: 6/1/2023 11:06 AM Saved By: Robin
Plot Date: 6/1/2023 11:32 AM Plot By: Robin Filename: M:\A22-029 FNI-Bird Island (Texas)\CAD\4 Plan View.dwg



SECTION A 3|5



SECTION B 3|5

NOTES:

1. BORROW AREA A CONTAINS APPROXIMATLY 30,100 CUBIC YARDS OF MATERIAL.
2. BORROW AREA B CONTAINS APPROXIMATLY 27,000 CUBIC YARDS OF MATERIAL.

10' 0 10' 20'
HORIZONTAL SCALE: 1"=10'

10' 0 10' 20'
VERTICAL SCALE: 1"=10'

90% SUBMITTAL

THIS DOCUMENT IS RELEASED FOR THE PURPOSE OF INTERIM REVIEW UNDER THE AUTHORITY OF: MATT SALMON P.E. TEXAS NO: 143709 ON DATE: 6/01/2023 IT IS NOT TO BE USED FOR CONSTRUCTION, BIDDING OR PERMIT PURPOSES.

Freese and Nichols, Inc.
Texas Registered Engineering Firm F-2144

F&N JOB NO.	ADB20155
DATE	6/01/2023
SCALE	
DESIGNED	MLS
DRAFTED	SDC
FILE	5 Borrow Typical Sec.dwg

AUDUBON TEXAS

CARANCAHUA BAY MOUTH ROOKERY ISLAND

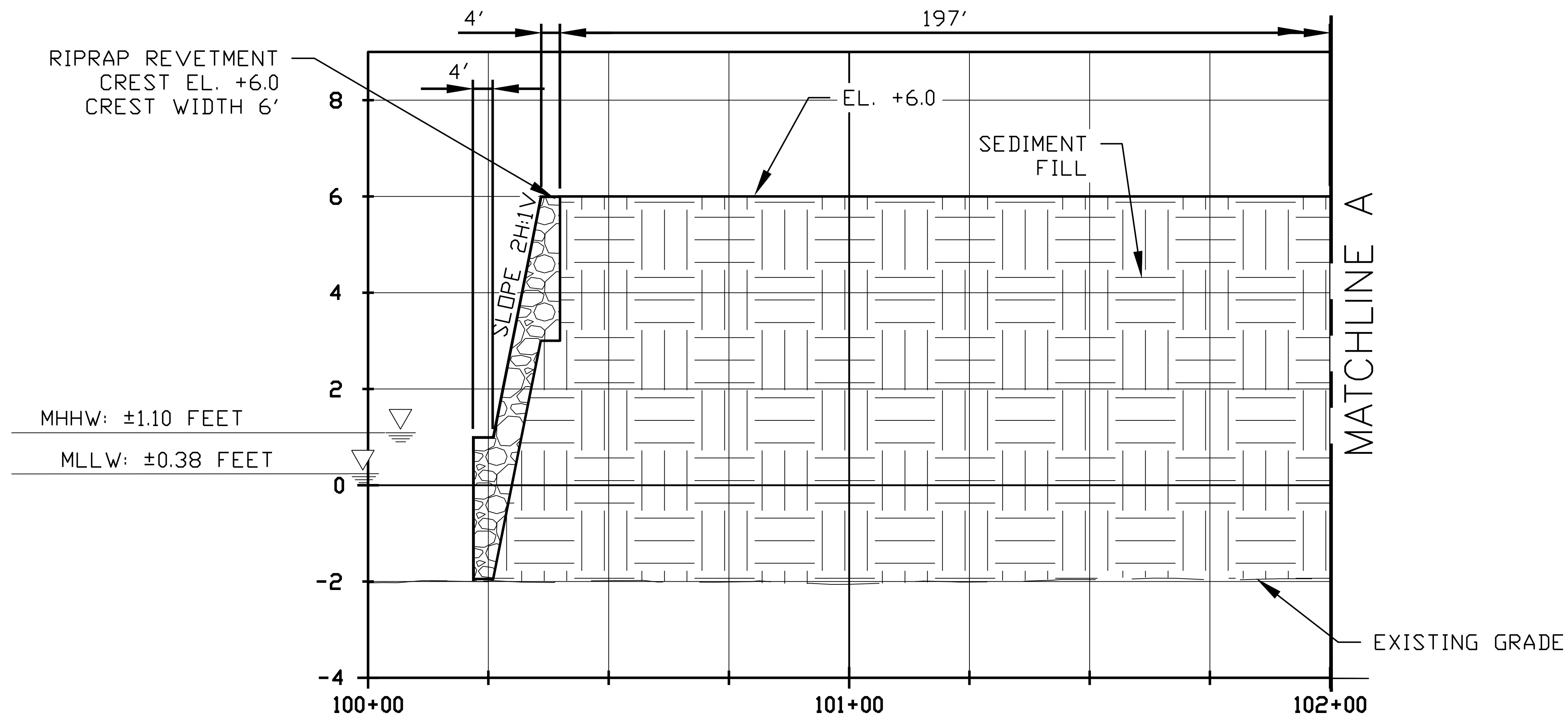
BORROW AREA TYPICAL SECTIONS

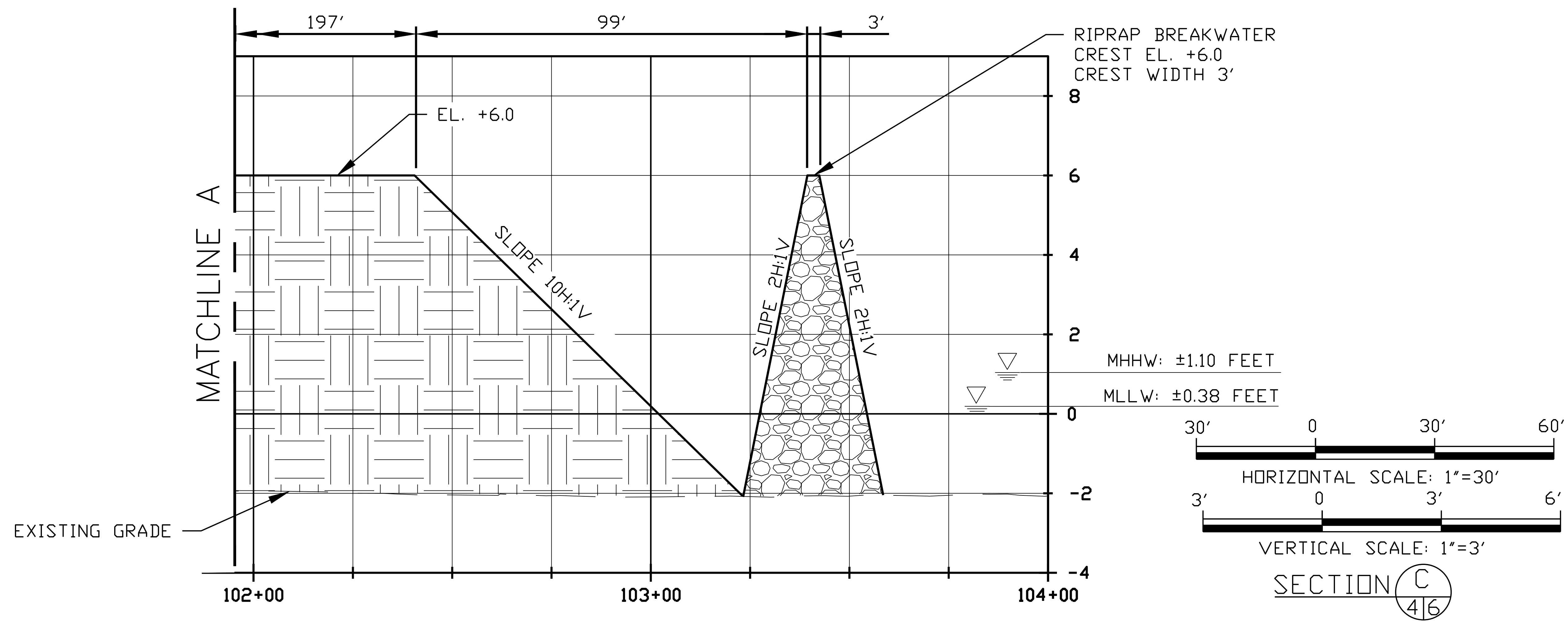
FREESE NICHOLS
10431 Morado Circle, Suite 300
Austin, Texas 78759
Phone - (512) 617-3100
Web - www.freese.com

5
SHEET

ACAD Rel: 23.0s (LMS Tech)
Filename: M:\A22-029 FNI-Bird Island (Texas)\CAD\5 Borrow Typical Sec.dwg
Last Saved: 5/15/2023 1:15 PM Saved By: Robin

Plot Date: 6/1/2023 11:32 AM Plot By: Robin Filename: M:\A22-029 FNI-Bird Island (Texas)\CAD\5 Borrow Typical Sec.dwg





90% SUBMITTAL

THIS DOCUMENT IS RELEASED FOR THE PURPOSE OF INTERIM REVIEW UNDER THE AUTHORITY OF: MATT SALMON P.E. TEXAS NO: 143709 ON DATE: 6/01/2023 IT IS NOT TO BE USED FOR CONSTRUCTION, BIDDING OR PERMIT PURPOSES.

Freese and Nichols, Inc.
Texas Registered Engineering Firm F-2144

F&N JOB NO. ADB20155
DATE 6/01/2023
SCALE
DESIGNED MLS
DRAFTED RH
FILE 6 Typical Section.dwg

AUDUBON TEXAS

CARANCAHUA BAY MOUTH ROOKERY ISLAND

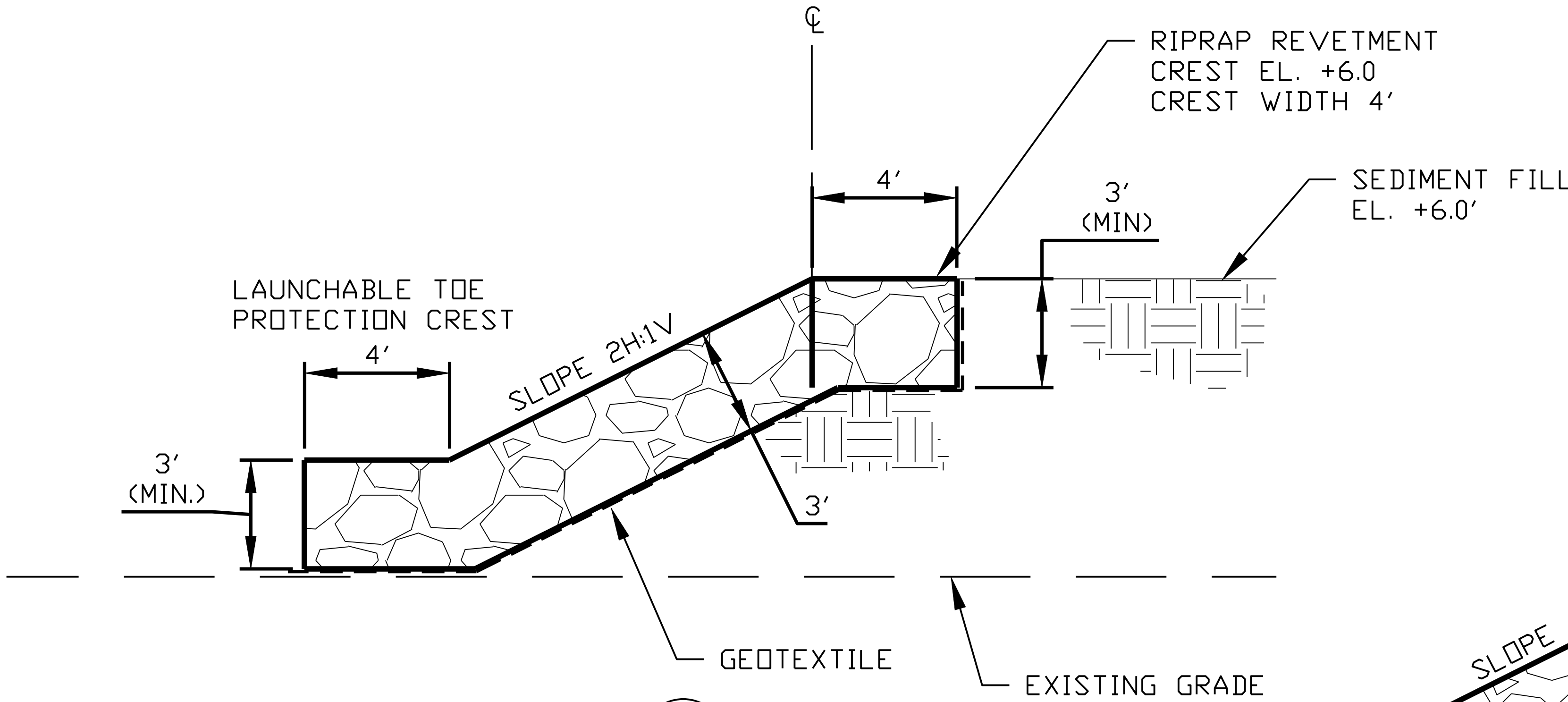
ISLAND TYPICAL SECTION

FREESE NICHOLS
10431 Morado Circle, Suite 300
Austin, Texas 78759
Phone - (512) 617-3100
Web - www.freese.com

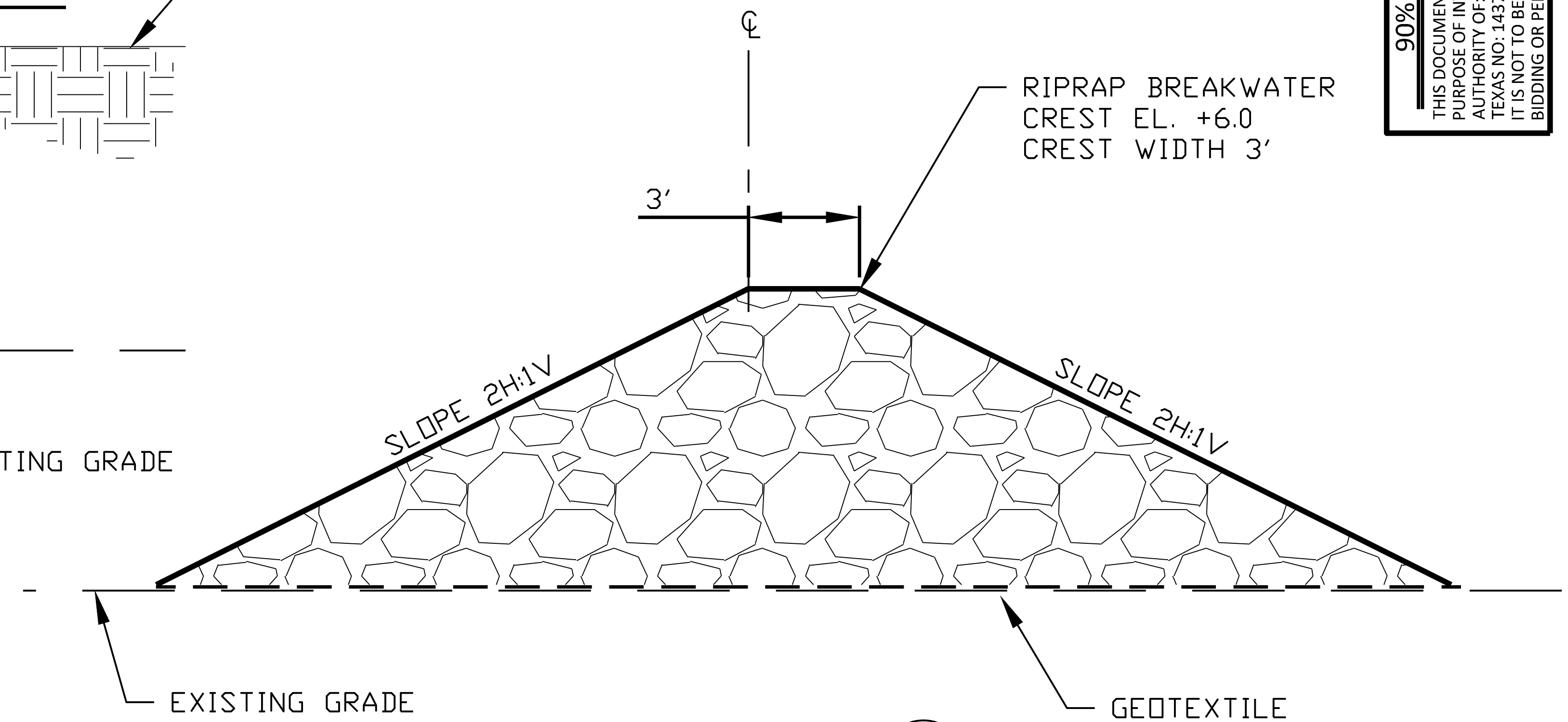
6
SHEET

ACAD Rel: 23.0s (LMS Tech)
Filename: M:\A22-029 FNI-Bird Island (Texas)\CAD\6 Typical Section.dwg
Last Saved: 6/1/2023 11:07 AM Saved By: Robin

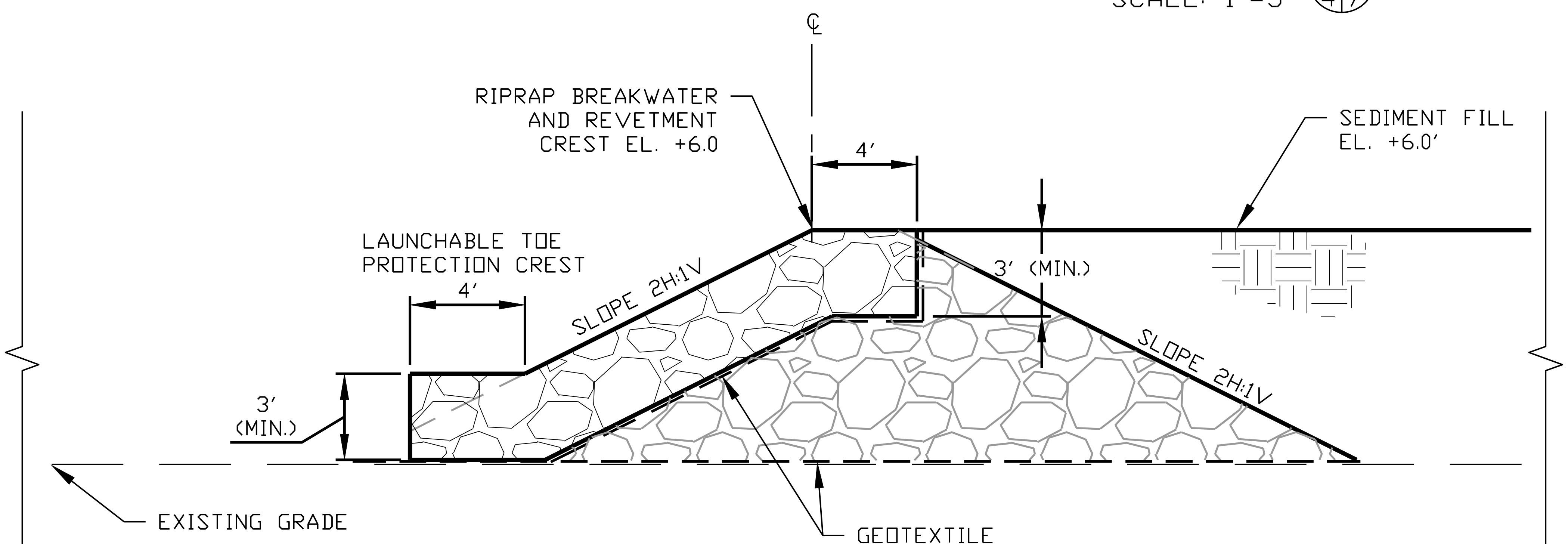
Plot Date: 6/1/2023 11:32 AM Plot By: Robin Filename: M:\A22-029 FNI-Bird Island (Texas)\CAD\6 Typical Section.dwg



SECTION D 4|7
SCALE: 1"=5'



SECTION E 4|7
SCALE: 1"=5'



TRANSITION DETAIL F 4|7
SCALE: 1"=5'

NOTES:
1. MEDIAN STONE WEIGHT FOR BREAKWATER AND REVETMENT IS 240 POUNDS WITH AN APPROXIMATE DIAMETER OF 1.3 FEET.
2. TOE AND CREST STONE TO BE PLACED TO NATURAL ANGLE OF REPOSE WHICH MAY BE STEEPER THAN 2:1 (H:V).

90% SUBMITTAL
THIS DOCUMENT IS RELEASED FOR THE PURPOSE OF INTERIM REVIEW UNDER THE AUTHORITY OF: MATT SALMON P.E. TEXAS NO: 143709 ON DATE: 6/01/2023 IT IS NOT TO BE USED FOR CONSTRUCTION, BIDDING OR PERMIT PURPOSES.

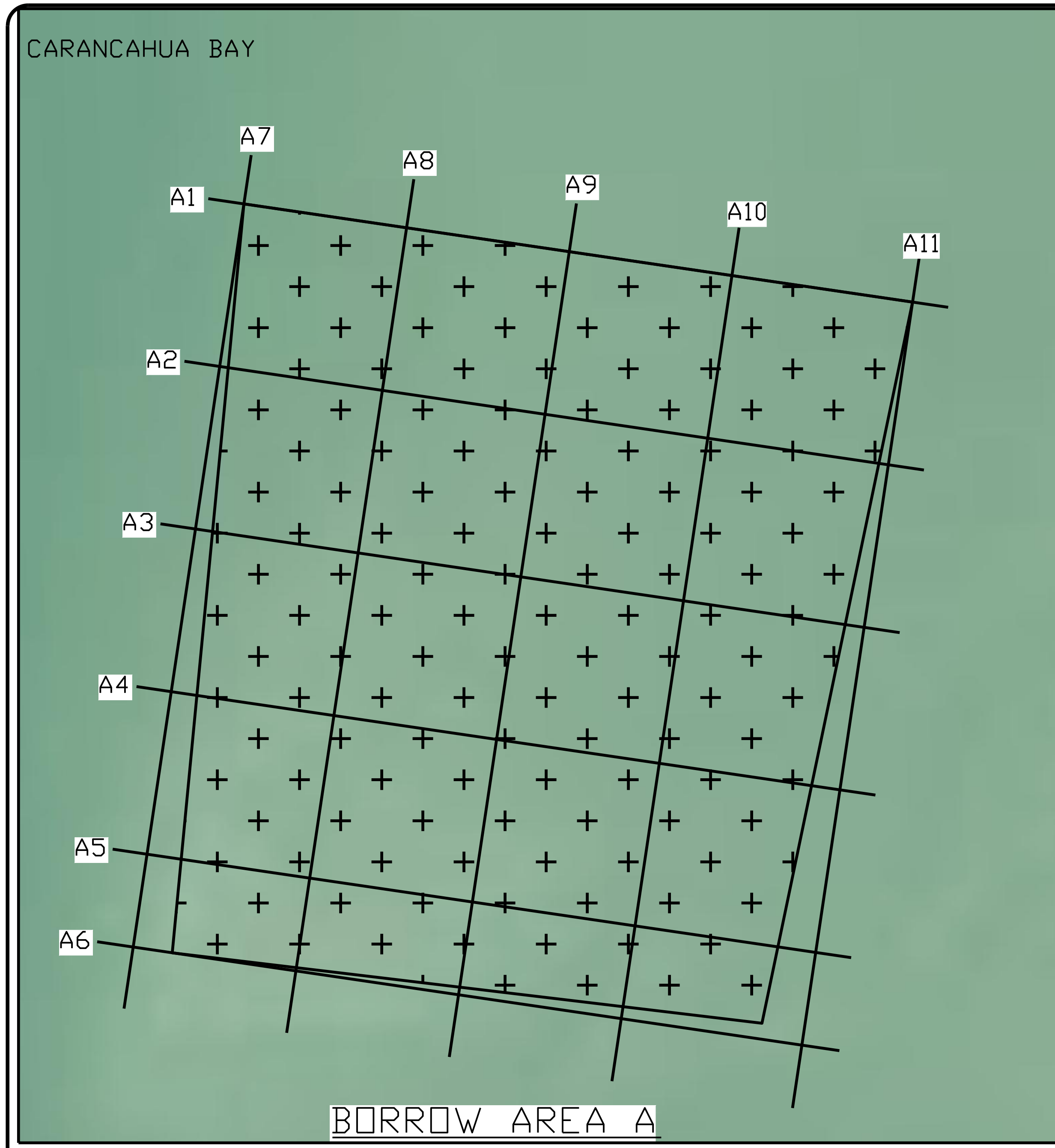
Freese and Nichols, Inc.
Texas Registered Engineering Firm F-2144

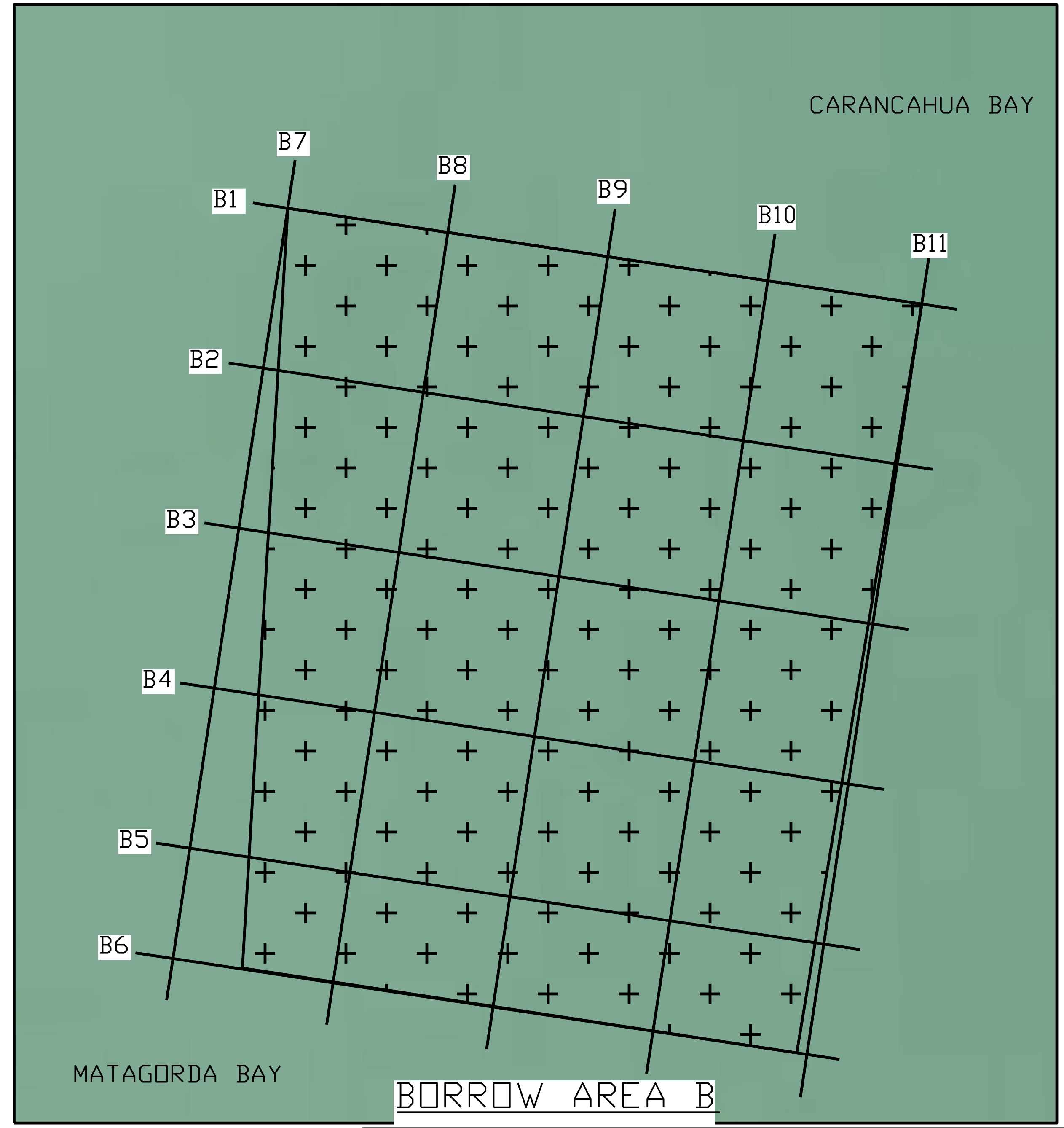
AUDUBON TEXAS
CARANCAHUA BAY MOUTH ROOKERY ISLAND
REVETMENT AND BREAKWATER TYPICAL SECTIONS

F&N JOB NO.	ADB20155
DATE	6/01/2023
SCALE	
DESIGNED	MLS
DRAFTED	RH
FILE	7 Revet Detail Section.dwg

FREESE NICHOLS
10431 Morado Circle, Suite 300
Austin, Texas 78759
Phone - (512) 617-3100
Web - www.freese.com

ACAD Rel: 23.0s (LMS Tech)
Filename: M:\A22-029 FNI-Bird Island (Texas)\CAD\7 Revet Detail Section.dwg
Last Saved: 6/1/2023 11:57 AM Saved By: Robin
Plot Date: 6/1/2023 11:58 AM Plot By: Robin Filename: M:\A22-029 FNI-Bird Island (Texas)\CAD\7 Revet Detail Section.dwg





BORROW AREA A				
NO.	BEGIN NORTHING	BEGIN EASTING	END NORTHING	END EASTING
A1	13,420,978.52	2,812,575.77	13,420,912.46	2,813,025.69
A2	13,420,879.59	2,812,561.23	13,420,813.46	2,813,010.95
A3	13,420,780.66	2,812,546.68	13,420,714.55	2,81,996.22
A4	13,420,681.72	2,812,532.13	13,420,615.64	2,812,981.49
A5	13,420,582.78	2,812,517.58	13,420,516.74	2,812,966.76
A6	13,420,526.43	2,812,508.21	13,420,460.19	2,812,959.53
A7	13,421,005.05	2,812,601.86	13,420,485.77	2,812,524.54
A8	13,420,990.32	2,812,700.77	13,420,471.04	2,812,623.45
A9	13,420,975.59	2,812,799.68	13,420,456.31	2,812,722.36
A10	13,420,960.86	2,812,898.59	13,420,441.58	2,812,821.26
A11	13,420,944.53	2,81,3008.39	13,420,425.26	2,812,931.06

100′ 0 100′ 500′

SCALE: 1″=100′

BORROW AREA B				
NO.	BEGIN NORTHING	BEGIN EASTING	END NORTHING	END EASTING
B1	13,419,738.71	2,81,1123.64	13,419,672.95	2,811,558.70
B2	13,419,639.84	2,811,108.70	13,419,574.08	2,81,1543.76
B3	13,419,540.96	2,811,093.75	13,419,475.20	2,81,1528.81
B4	13,419,442.08	2,811,078.81	13,419,376.32	2,811,513.87
B5	13,419,343.21	2,811,063.86	13,419,277.45	2,81,1498.92
B6	13,419,275.38	2,811,051.16	13,419,209.62	2,811,486.21
B7	13,419,765.13	2,81,1149.84	13,419,246.17	2,81,1070.43
B8	13,419,750.00	2,811,248.69	13,419,231.04	2,811,169.28
B9	13,419,734.87	2,811,347.54	13,419,215.91	2,811,268.12
B10	13,419,719.75	2,811,446.39	13,419,200.79	2,811,366.97
B11	13,419,705.19	2,811,541.49	13,419,186.23	2,811,462.07

90% SUBMITTAL

THIS DOCUMENT IS RELEASED FOR THE PURPOSE OF INTERIM REVIEW UNDER THE AUTHORITY OF: MATT SALMON P.E. TEXAS NO: 143709 ON DATE: 6/01/2023 IT IS NOT TO BE USED FOR CONSTRUCTION, BIDDING OR PERMIT PURPOSES.

Freese and Nichols, Inc.
Texas Registered Engineering Firm F-2144

F&N JOB NO. ADB20155
DATE 6/01/2023
SCALE
DESIGNED MLS
DRAFTED RH
FILE 8 Borrow Area Sec Plan.dwg

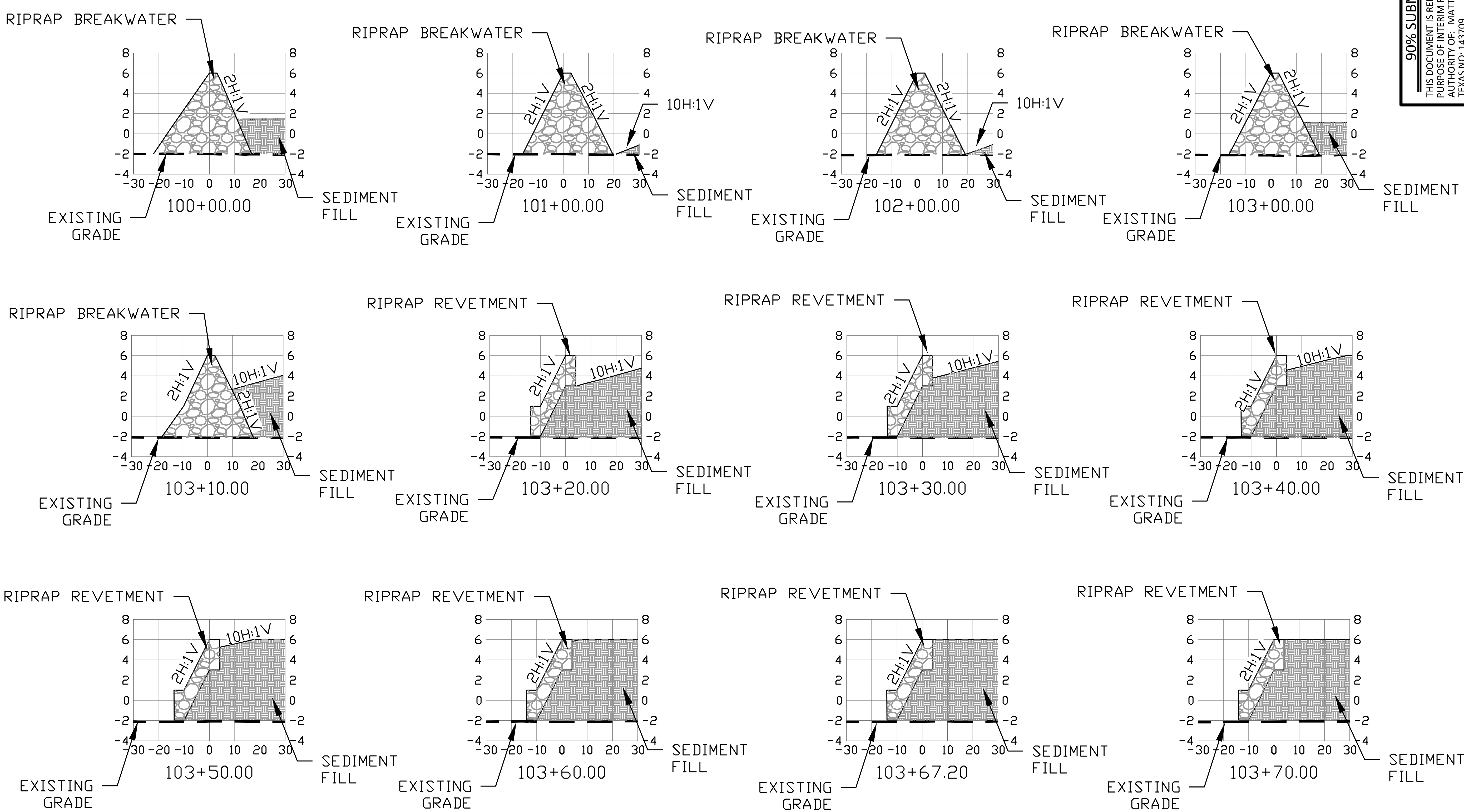
AUDUBON TEXAS

CARANCAHUA BAY MOUTH ROOKERY ISLAND

BORROW AREA LAYOUT

FREESE NICHOLS
10431 Morado Circle,
Suite 300
Austin, Texas 78759
Phone - (512) 617-3100
Web - www.freese.com

ACAD Rel: 23.0s (LMS Tech)
Filename: M:\A22-029 FNI-Bird Island (Texas)\CAD\8 Borrow Area Sec Plan.dwg
Last Saved: 5/15/2023 1:10 PM Saved By: Robin
Plot Date: 6/1/2023 11:33 AM Plot By: Robin Filename: M:\A22-029 FNI-Bird Island (Texas)\CAD\8 Borrow Area Sec Plan.dwg



40′ 0 40′ 80′

HORIZONTAL SCALE: 1″=40′

10′ 0 10′ 20′

VERTICAL SCALE: 1″=10′

90% SUBMITTAL

THIS DOCUMENT IS RELEASED FOR THE PURPOSE OF INTERIM REVIEW UNDER THE AUTHORITY OF: MATT SALMON P.E. TEXAS NO: 143709 ON DATE: 6/01/2023 IT IS NOT TO BE USED FOR CONSTRUCTION, BIDDING OR PERMIT PURPOSES.

Freese and Nichols, Inc.
Texas Registered Engineering Firm F-2144

F&N JOB NO.	ADB20155
DATE	6/01/2023
SCALE	
DESIGNED	MLS
DRAFTED	RH
FILE	9-14 Cross Sections.dwg

AUDUBON TEXAS

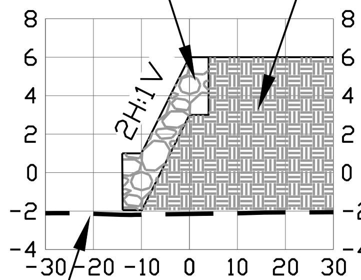
CARANCAHUA BAY MOUTH ROOKERY ISLAND

REVETMENT AND BREAKWATER CROSS SECTIONS

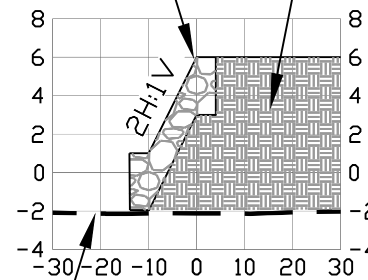
FREESE NICHOLS
10431 Morado Circle, Suite 300
Austin, Texas 78759
Phone - (512) 617-3100
Web - www.freese.com

ACAD Rel: 23.0s (LMS Tech)
Filename: M:\A22-029 FNI-Bird Island (Texas)\CAD\9-14 Cross Sections.dwg
Last Saved: 6/1/2023 1:19 PM Saved By: Robin

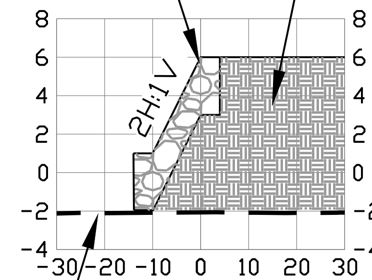
Plot Date: 6/1/2023 1:21 PM Plot By: Robin Filename: M:\A22-029 FNI-Bird Island (Texas)\CAD\9-14 Cross Sections.dwg



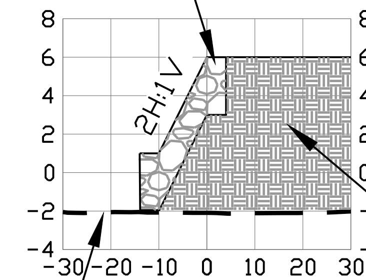
103+80.00



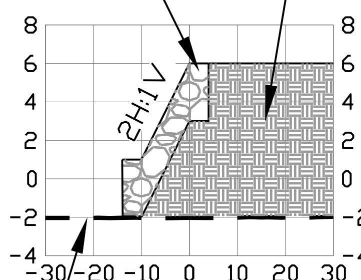
103+90.00



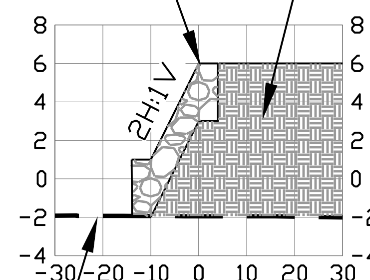
104+00.00



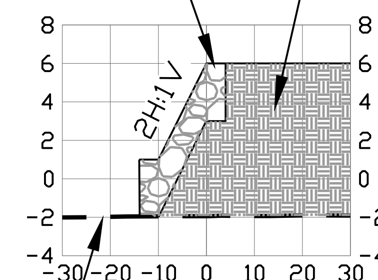
105+00.00



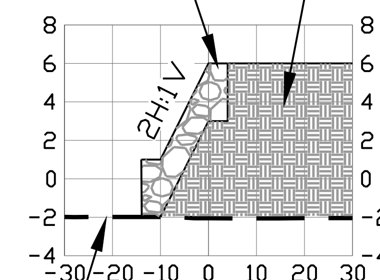
106+00.00



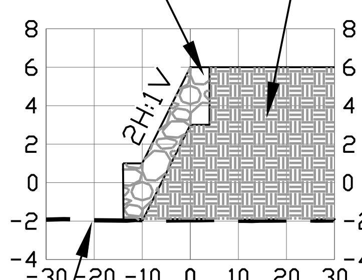
107+00.00



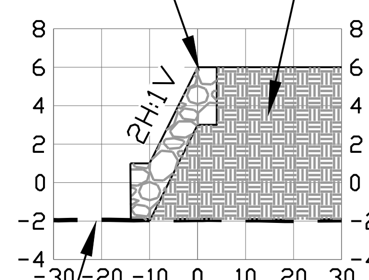
108+00.00



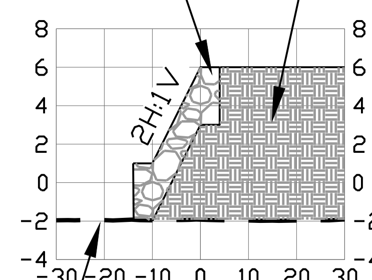
109+00.00



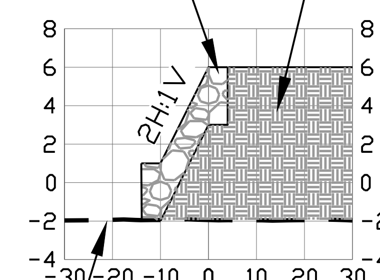
110+00.00



111+00.00



111+10.00



111+20.00

40′ 0 40′ 80′
HORIZONTAL SCALE: 1″=40′

10′ 0 10′ 20′
VERTICAL SCALE: 1″=10′

90% SUBMITTAL
THIS DOCUMENT IS RELEASED FOR THE PURPOSE OF INTERIM REVIEW UNDER THE AUTHORITY OF: MATT SALMON P.E. TEXAS NO: 143709 ON DATE: 6/01/2023 IT IS NOT TO BE USED FOR CONSTRUCTION, BIDDING OR PERMIT PURPOSES.

Freese and Nichols, Inc.
Texas Registered Engineering Firm F-2144

AUDUBON TEXAS
CARANCAHUA BAY MOUTH ROOKERY ISLAND
REVETMENT AND BREAKWATER CROSS SECTIONS

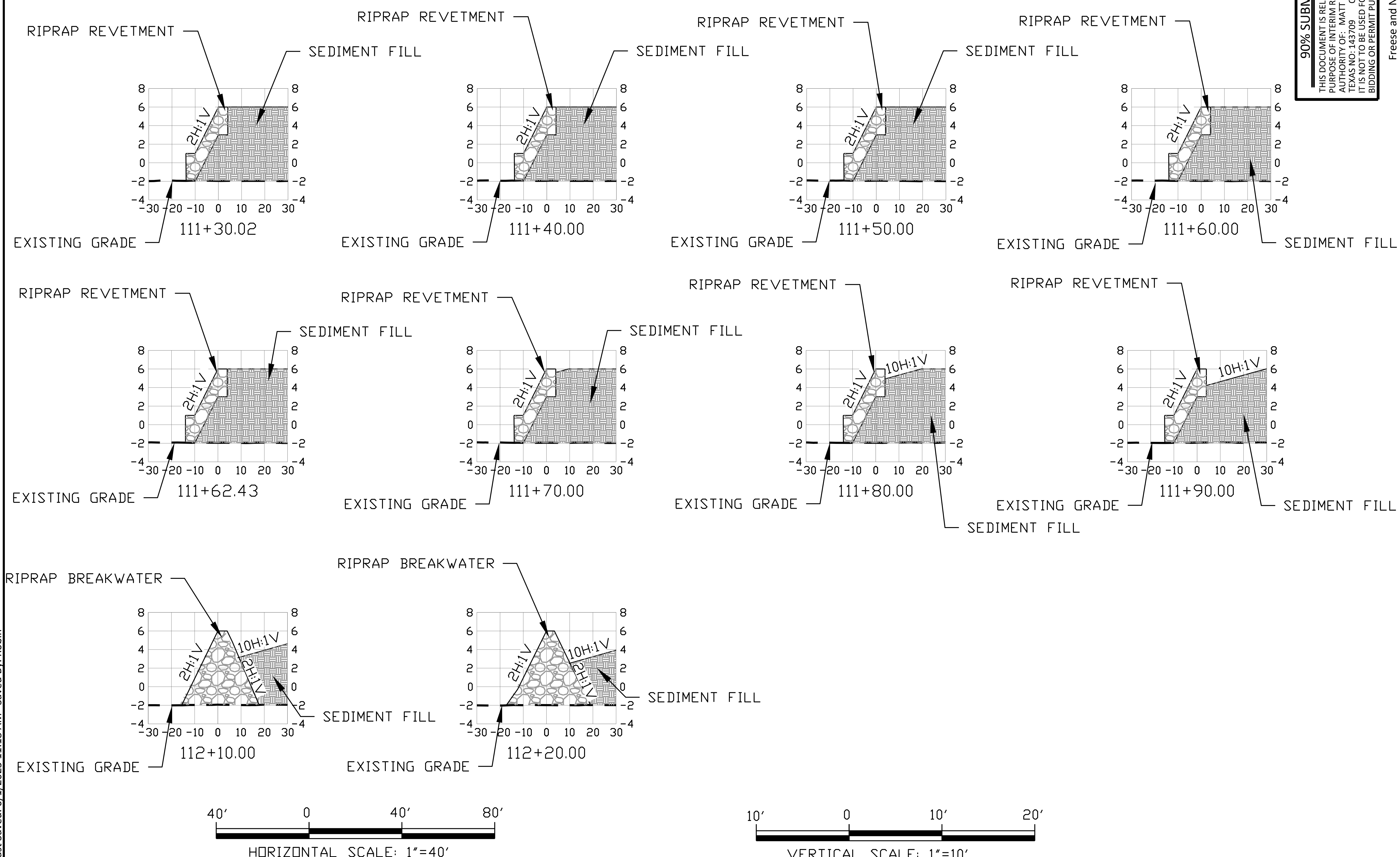
FREESE AND NICHOLS
10431 Morado Circle, Suite 300
Austin, Texas 78759
Phone - (512) 617-3100
Web - www.freese.com

F&N JOB NO. ADB20155
DATE 6/01/2023
SCALE
DESIGNED MLS
DRAFTED RH
FILE 9-14 Cross Sections.dwg

10
SHEET

ACAD Rel: 23.0s (LMS Tech)
Filename: M:\A22-029 FNI-Bird Island (Texas)\CAD\9-14 Cross Sections.dwg
Last Saved: 6/1/2023 11:18 AM Saved By: Robin

Plot Date: 6/1/2023 11:33 AM Plot By: Robin Filename: M:\A22-029 FNI-Bird Island (Texas)\CAD\9-14 Cross Sections.dwg



90% SUBMITTAL

THIS DOCUMENT IS RELEASED FOR THE PURPOSE OF INTERIM REVIEW UNDER THE AUTHORITY OF: MATT SALMON P.E. TEXAS NO: 143709 ON DATE: 6/01/2023 IT IS NOT TO BE USED FOR CONSTRUCTION, BIDDING OR PERMIT PURPOSES.

Freese and Nichols, Inc.
Texas Registered Engineering Firm F-2144

F&N JOB NO.	ADB20155
DATE	6/01/2023
SCALE	
DESIGNED	MLS
DRAFTED	RH
FILE	9-14 Cross Sections.dwg

AUDUBON TEXAS

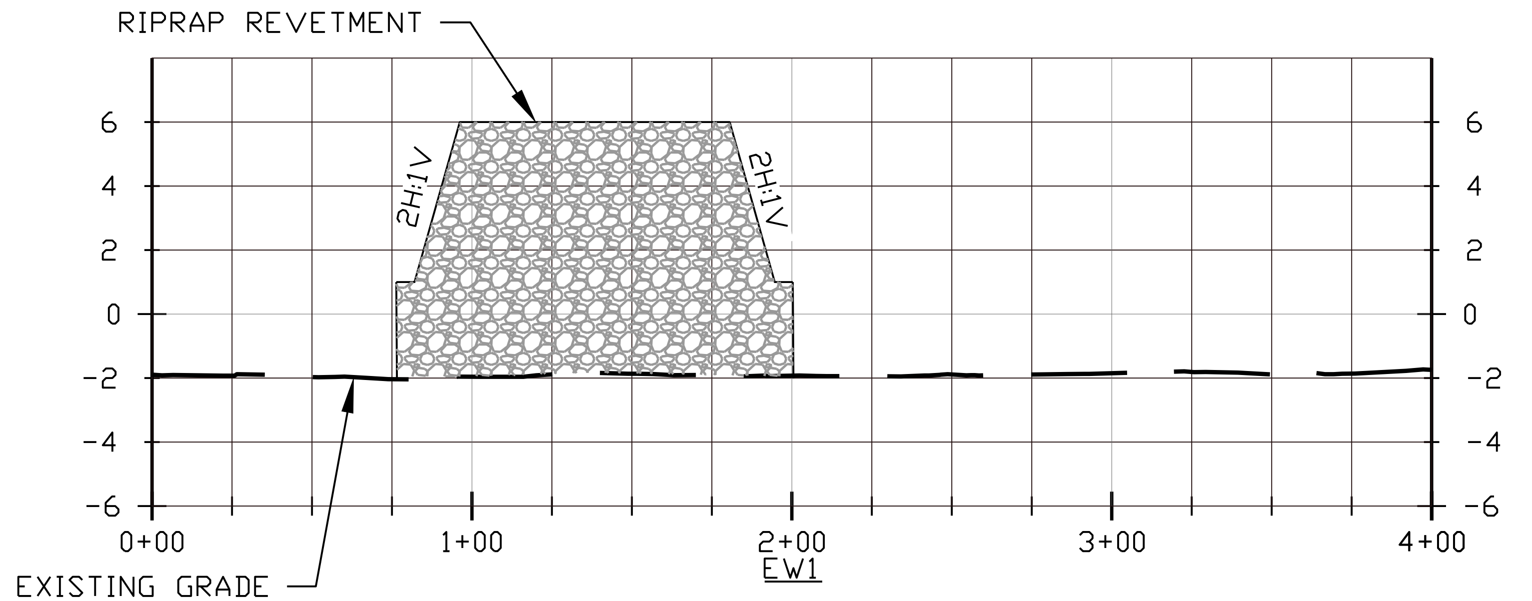
CARANCAHUA BAY MOUTH ROOKERY ISLAND

REVETMENT AND BREAKWATER CROSS SECTIONS

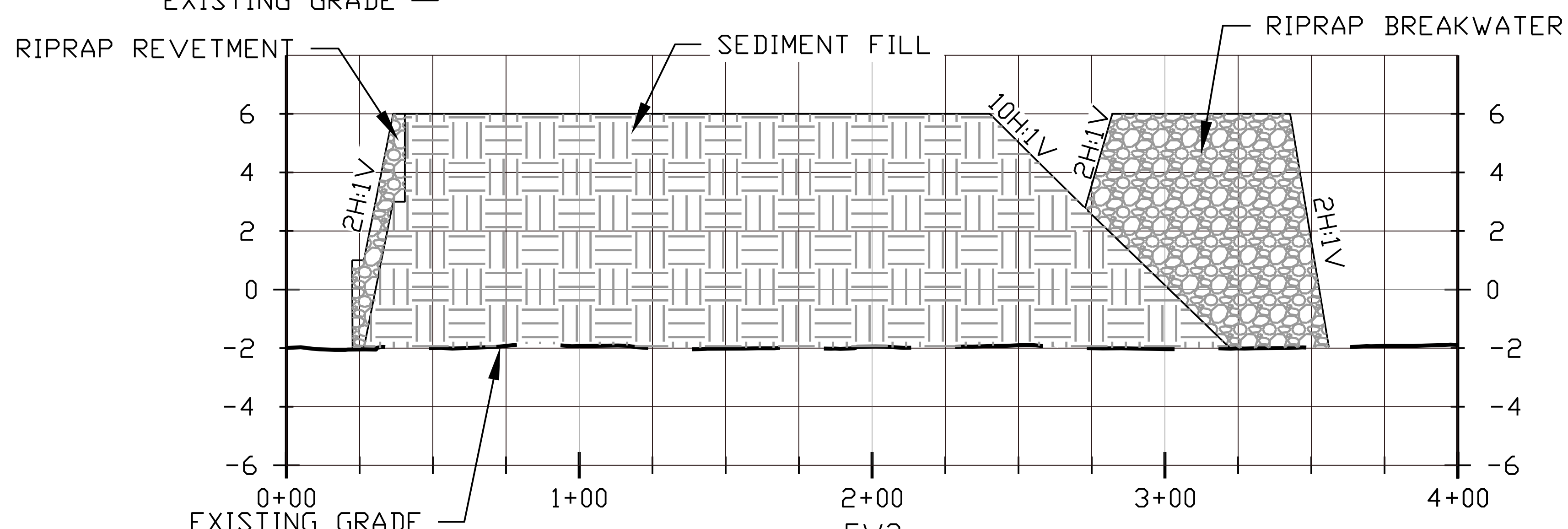
FREESE NICHOLS
10431 Morado Circle, Suite 300
Austin, Texas 78759
Phone - (512) 617-3100
Web - www.freese.com

ACAD Rel: 23.0s (LMS Tech)
Filename: M:\A22-029 FNI-Bird Island (Texas)\CAD\9-14 Cross Sections.dwg
Last Saved: 6/1/2023 11:18 AM Saved By: Robin

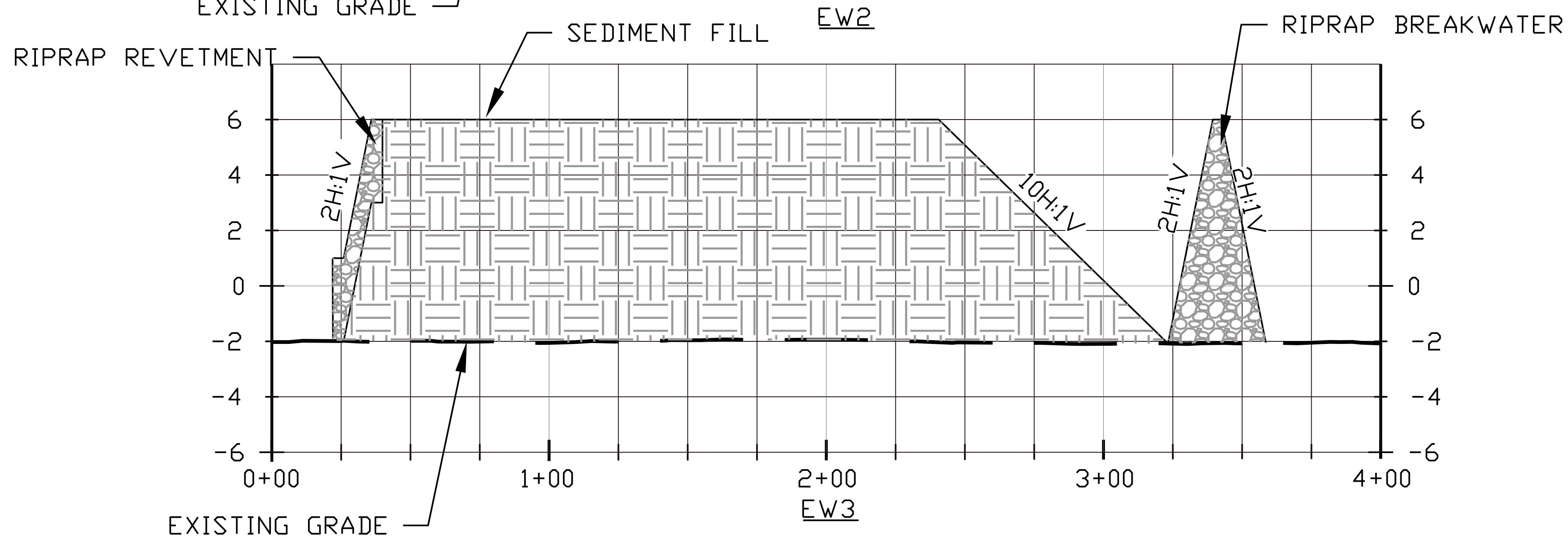
Plot Date: 6/1/2023 11:47 AM Plot By: Robin Filename: M:\A22-029 FNI-Bird Island (Texas)\CAD\9-14 Cross Sections.dwg



EW1



EW2



EW3

60′ 0 60′ 120′

HORIZONTAL SCALE: 1″=60′

10′ 0 10′ 20′

VERTICAL SCALE: 1″=10′

90% SUBMITTAL

THIS DOCUMENT IS RELEASED FOR THE PURPOSE OF INTERIM REVIEW UNDER THE AUTHORITY OF: MATT SALMON P.E. TEXAS NO: 143709 ON DATE: 6/01/2023 IT IS NOT TO BE USED FOR CONSTRUCTION, BIDDING OR PERMIT PURPOSES.

Freese and Nichols, Inc.
Texas Registered Engineering Firm F-2144

AUDUBON TEXAS

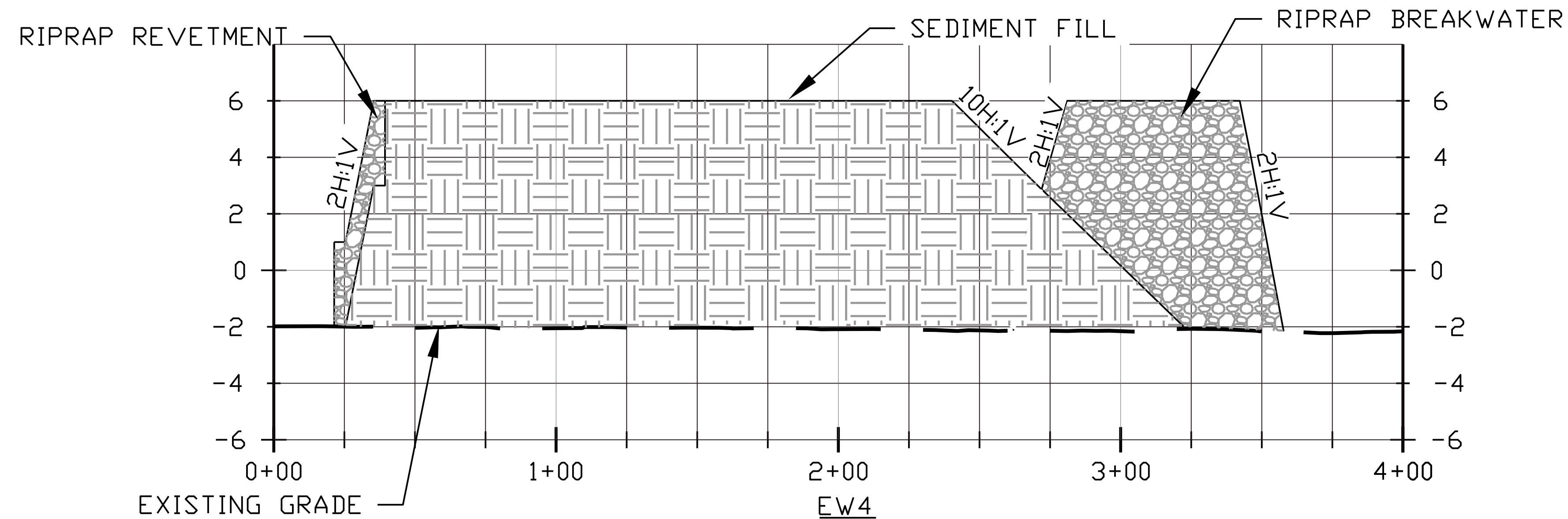
CARANCAHUA BAY MOUTH ROOKERY ISLAND

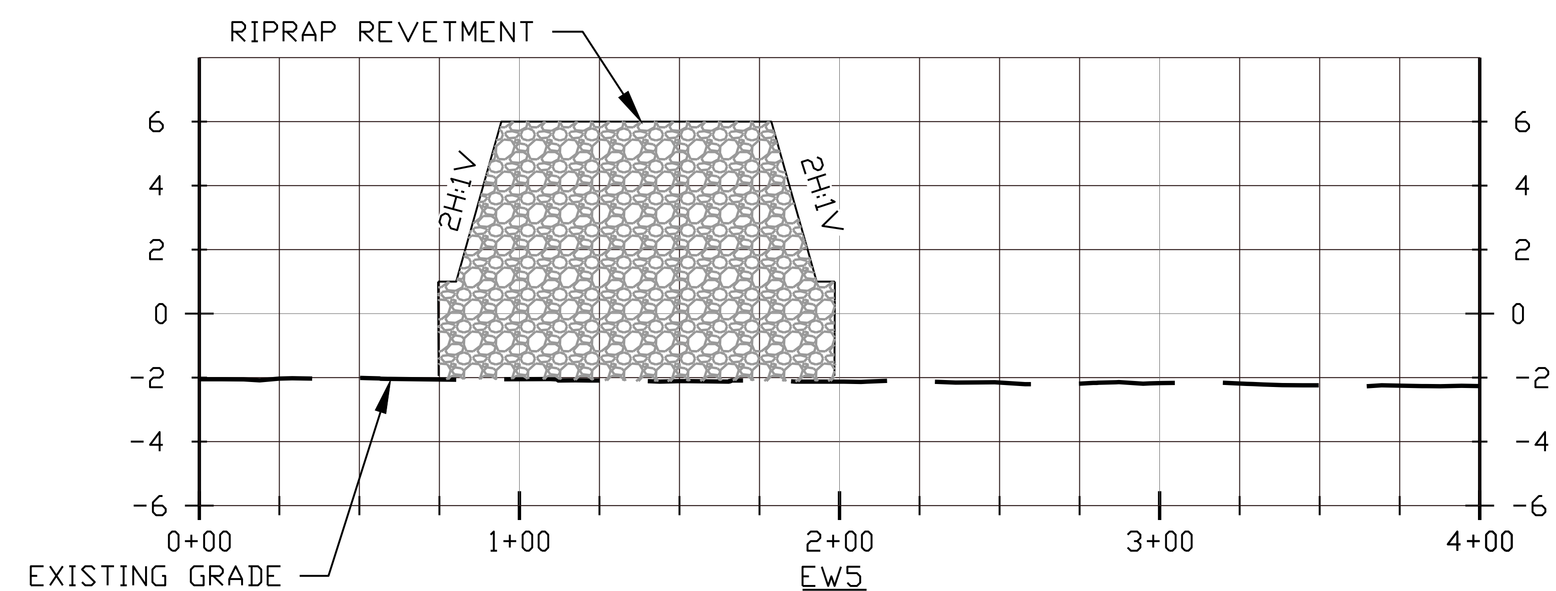
ISLAND CROSS SECTIONS

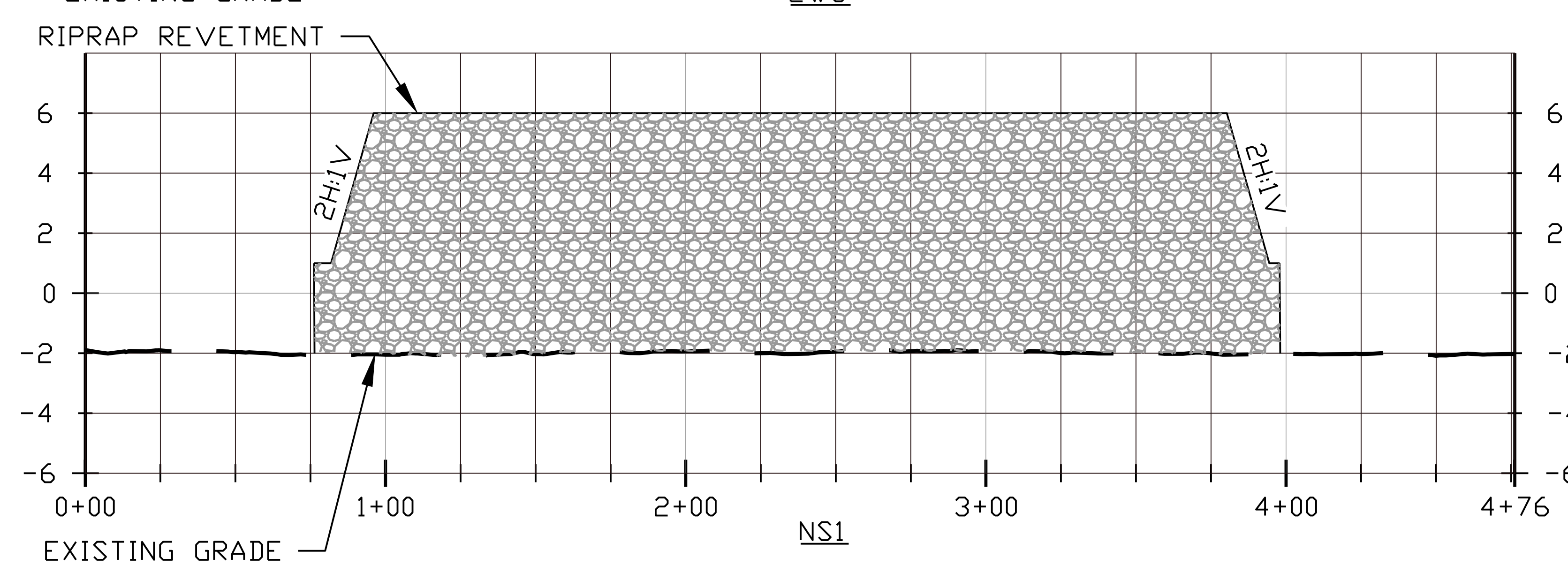
FREESE NICHOLS
10431 Morado Circle, Suite 300
Austin, Texas 78759
Phone - (512) 617-3100
Web - www.freese.com

F&N JOB NO.	ADB20155
DATE	6/01/2023
SCALE	
DESIGNED	MLS
DRAFTED	RH
FILE	9-14 Cross Sections.dwg

12
SHEET







90% SUBMITTAL

THIS DOCUMENT IS RELEASED FOR THE PURPOSE OF INTERIM REVIEW UNDER THE AUTHORITY OF: MATT SALMON P.E. TEXAS NO: 143709 ON DATE: 6/01/2023 IT IS NOT TO BE USED FOR CONSTRUCTION, BIDDING OR PERMIT PURPOSES.

Freese and Nichols, Inc.
Texas Registered Engineering Firm F-2144

F&N JOB NO.	ADB20155
DATE	6/01/2023
SCALE	
DESIGNED	MLS
DRAFTED	RH
FILE	9-14 Cross Sections.dwg

AUDUBON TEXAS

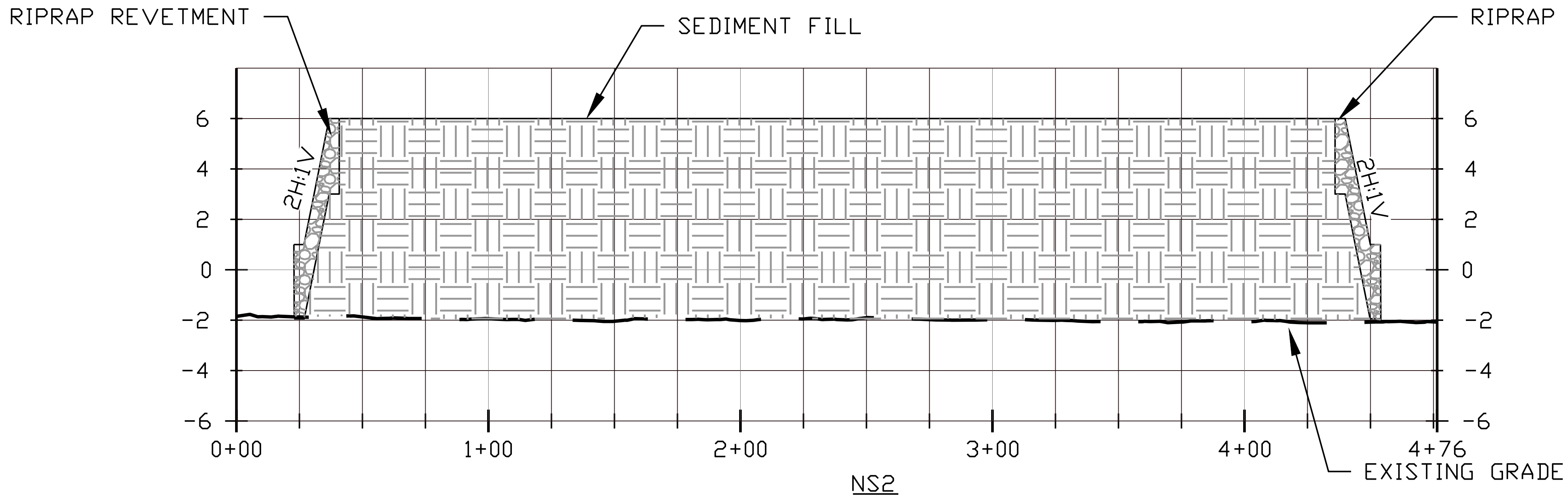
CARANCAHUA BAY MOUTH ROOKERY ISLAND

ISLAND CROSS SECTIONS

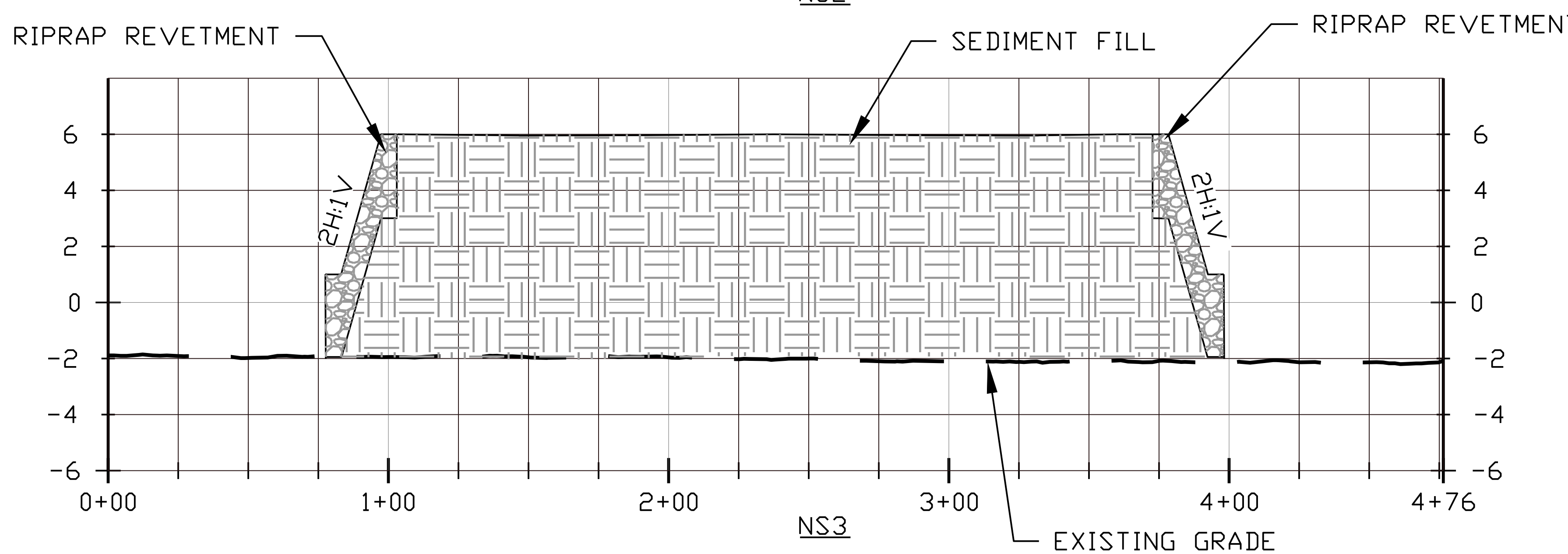
FREESE NICHOLS
10431 Morado Circle,
Suite 300
Austin, Texas 78759
Phone - (512) 617-3100
Web - www.freese.com

13
SHEET

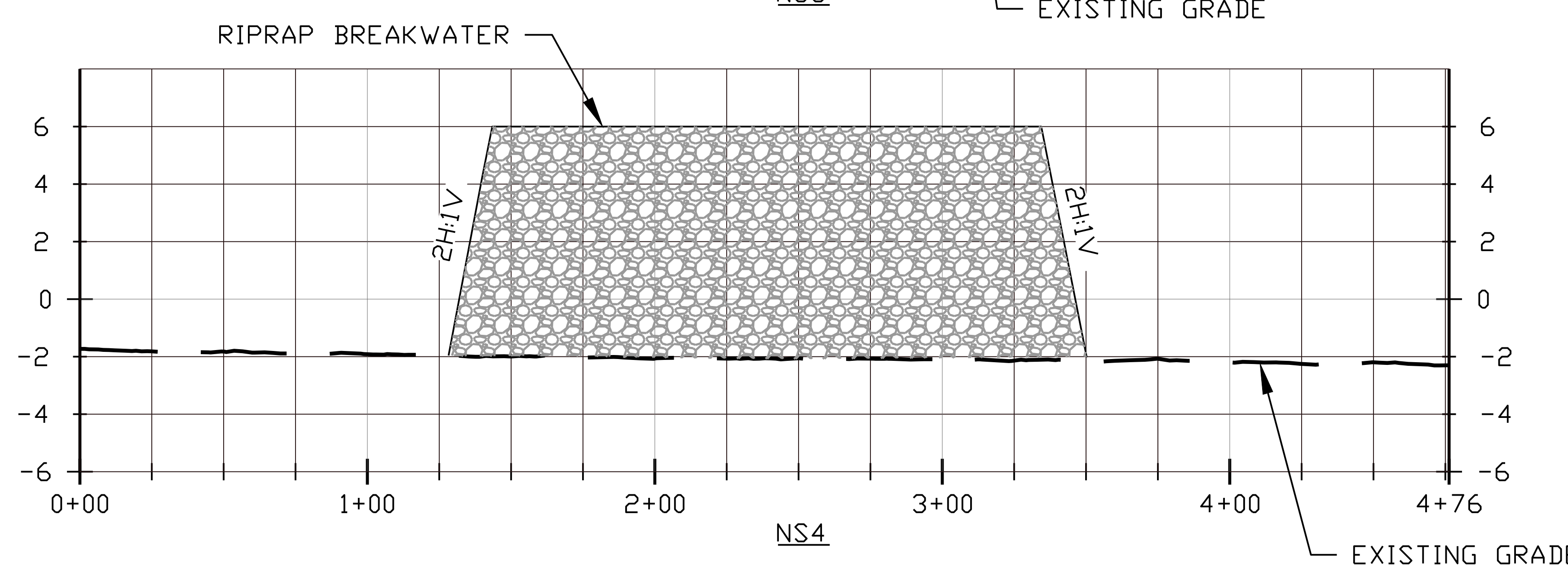
ACAD Rel: 23.0s (LMS Tech)
Filename: M:\A22-029 FNI-Bird Island (Texas)\CAD\9-14 Cross Sections.dwg
Last Saved: 6/1/2023 11:18 AM Saved By: Robin



NS2



NS3



NS4

90% SUBMITTAL

THIS DOCUMENT IS RELEASED FOR THE PURPOSE OF INTERIM REVIEW UNDER THE AUTHORITY OF: MATT SALMON P.E. TEXAS NO: 143709 ON DATE: 6/01/2023 IT IS NOT TO BE USED FOR CONSTRUCTION, BIDDING OR PERMIT PURPOSES.

Freese and Nichols, Inc.
Texas Registered Engineering Firm F-2144

F&N JOB NO.	ADB20155
DATE	6/01/2023
SCALE	
DESIGNED	MLS
DRAFTED	RH
FILE	9-14 Cross Sections.dwg

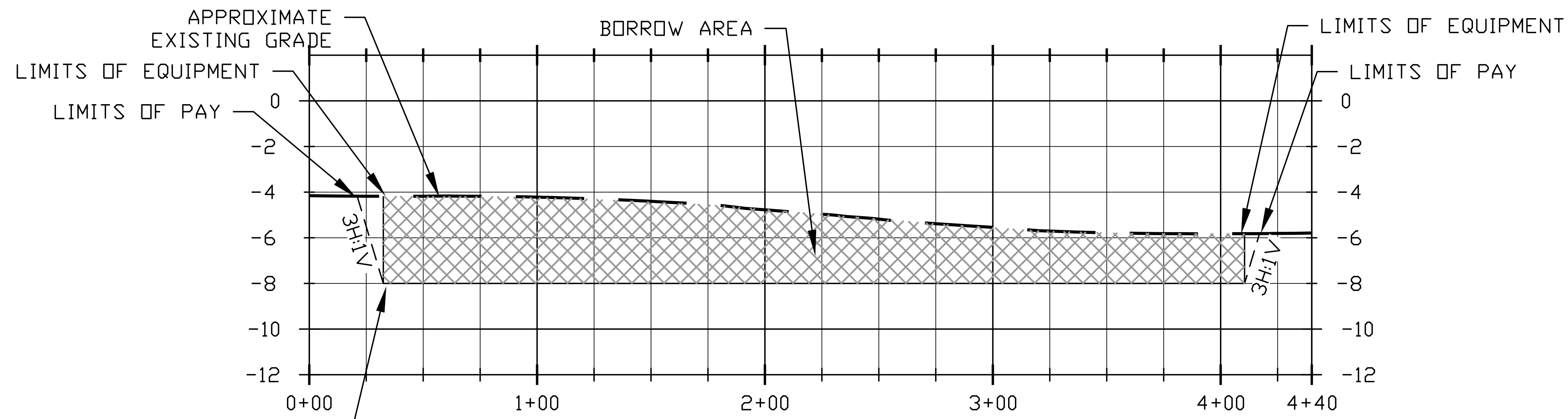
AUDUBON TEXAS

CARANCAHUA BAY MOUTH ROOKERY ISLAND

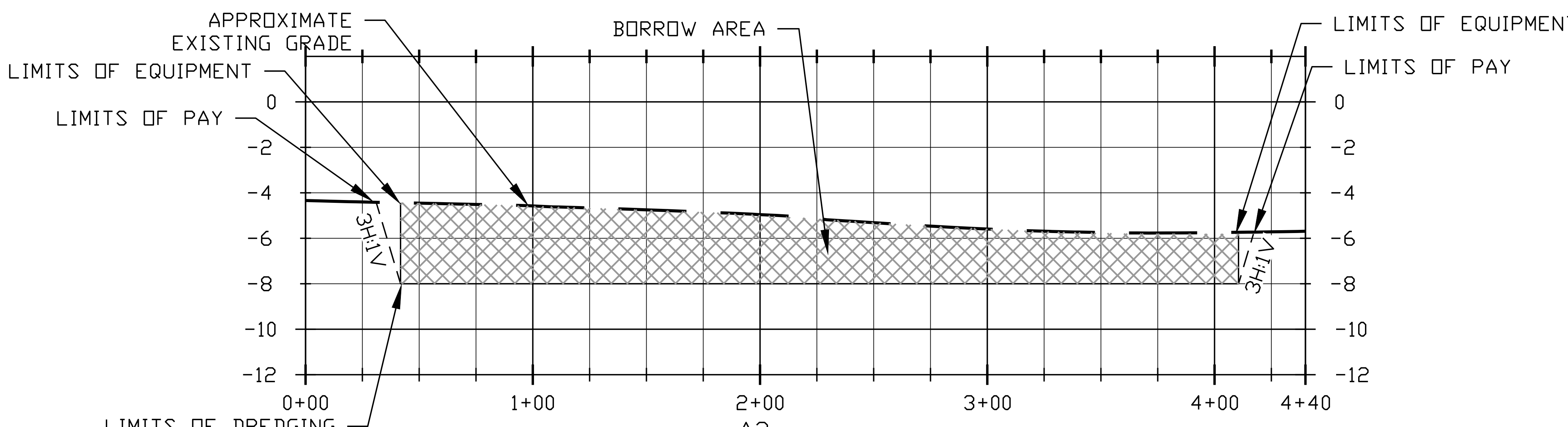
ISLAND CROSS SECTIONS

FREESE NICHOLS
10431 Morado Circle, Suite 300
Austin, Texas 78759
Phone - (512) 617-3100
Web - www.freese.com

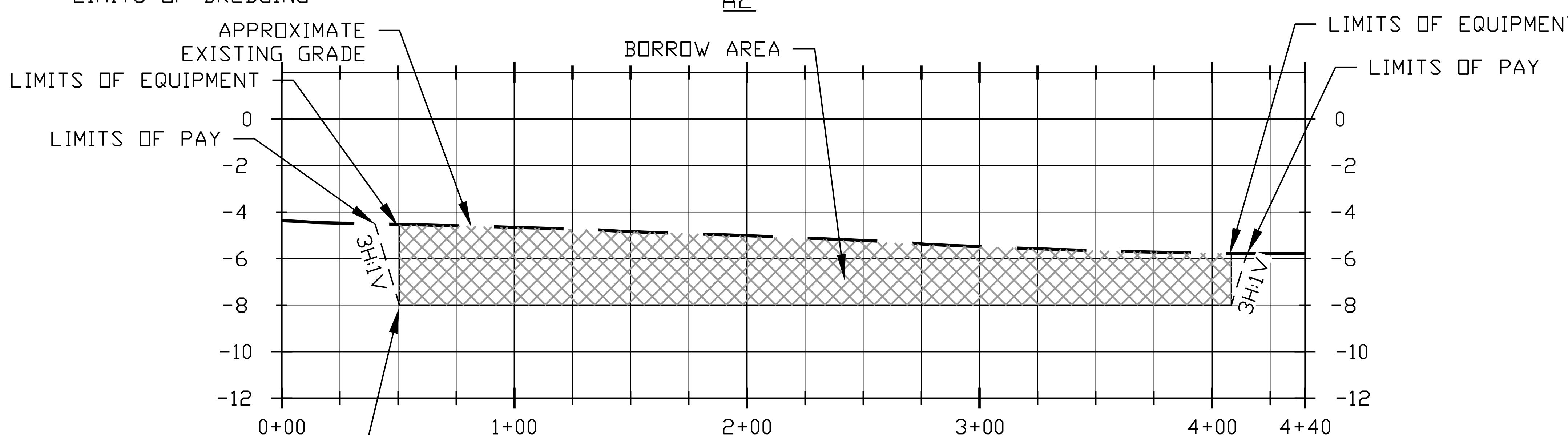
14
SHEET



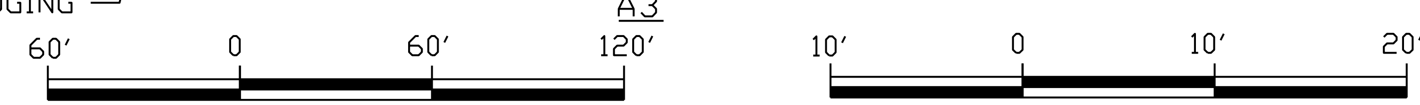
A1



A2



A3



HORIZONTAL SCALE: 1"=60'

VERTICAL SCALE: 1"=10'

90% SUBMITTAL

THIS DOCUMENT IS RELEASED FOR THE PURPOSE OF INTERIM REVIEW UNDER THE AUTHORITY OF: MATT SALMON P.E. TEXAS NO: 143709 ON DATE: 6/01/2023 IT IS NOT TO BE USED FOR CONSTRUCTION, BIDDING OR PERMIT PURPOSES.

Freese and Nichols, Inc.
Texas Registered Engineering Firm F-2144

F&N JOB NO. ADB20155
DATE 6/01/2023
SCALE
DESIGNED MLS
DRAFTED RH
FILE 15-22 Borrow Area CS.dwg

AUDUBON TEXAS

CARANCAHUA BAY MOUTH ROOKERY ISLAND

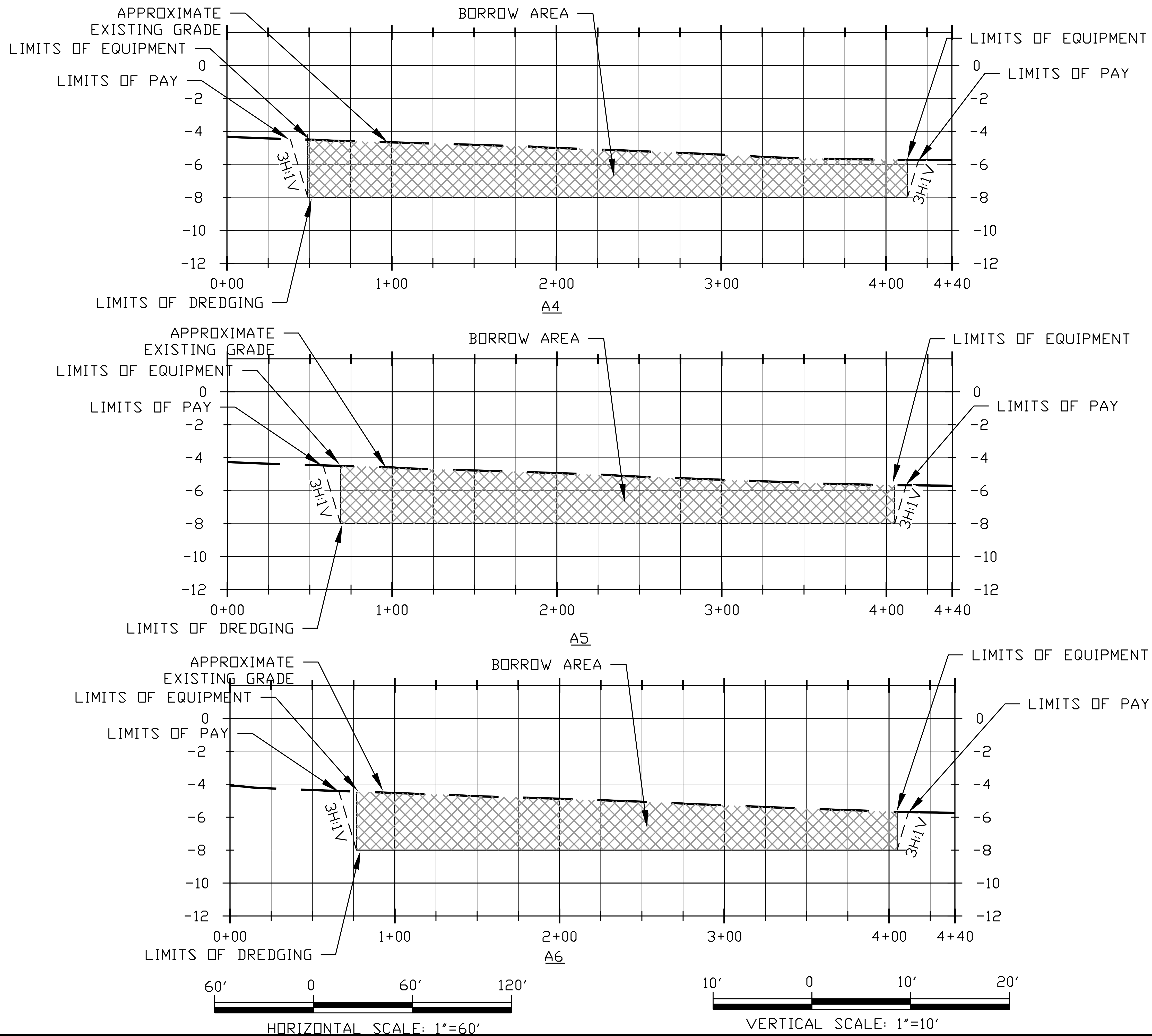
BORROW AREA CROSS SECTIONS

FREESE NICHOLS
10431 Morado Circle, Suite 300
Austin, Texas 78759
Phone - (512) 617-3100
Web - www.freese.com

15
SHEET

ACAD Rel: 23.0s (LMS Tech)
Filename: M:\A22-029 FNI-Bird Island (Texas)\CAD\15-22 Borrow Area CS.dwg
Last Saved: 5/15/2023 1:08 PM Saved By: Robin

Plot Date: 6/1/2023 11:33 AM Plot By: Robin Filename: M:\A22-029 FNI-Bird Island (Texas)\CAD\15-22 Borrow Area CS.dwg



ACAD Rel: 23.0s (LMS Tech)
Filename: M:\A22-029 FNI-Bird Island (Texas)\CAD\15-22 Borrow Area CS.dwg
Last Saved: 5/15/2023 1:08 PM Saved By: Robin

90% SUBMITTAL

THIS DOCUMENT IS RELEASED FOR THE PURPOSE OF INTERIM REVIEW UNDER THE AUTHORITY OF: MATT SALMON P.E. TEXAS NO: 143709 ON DATE: 6/01/2023 IT IS NOT TO BE USED FOR CONSTRUCTION, BIDDING OR PERMIT PURPOSES.

Freese and Nichols, Inc.
Texas Registered Engineering Firm F-2144

AUDUBON TEXAS

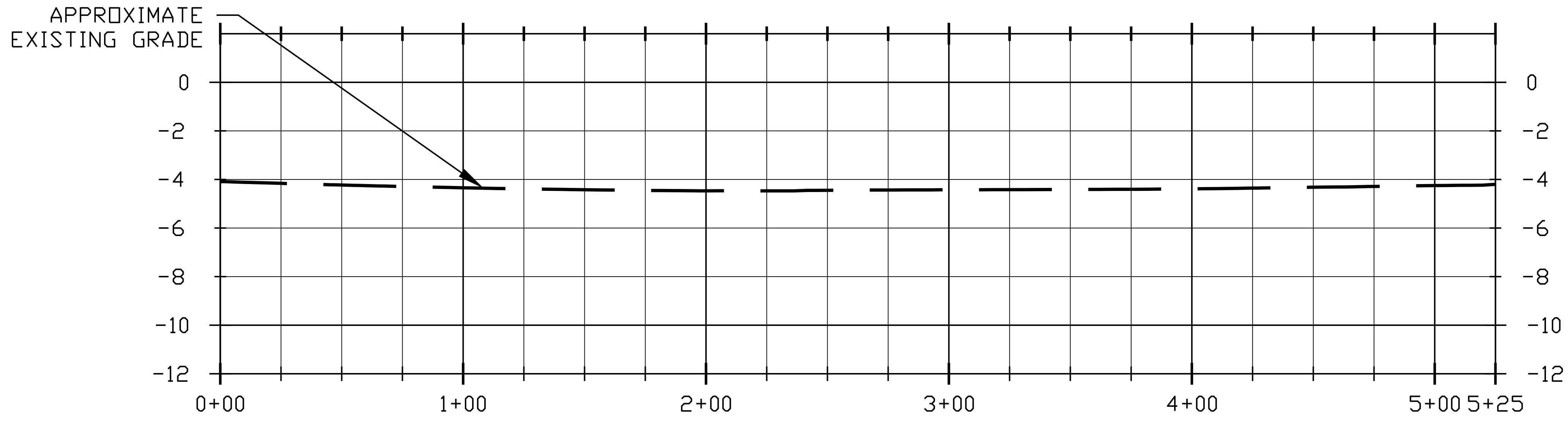
CARANCAHUA BAY MOUTH ROOKERY ISLAND

BORROW AREA CROSS SECTIONS

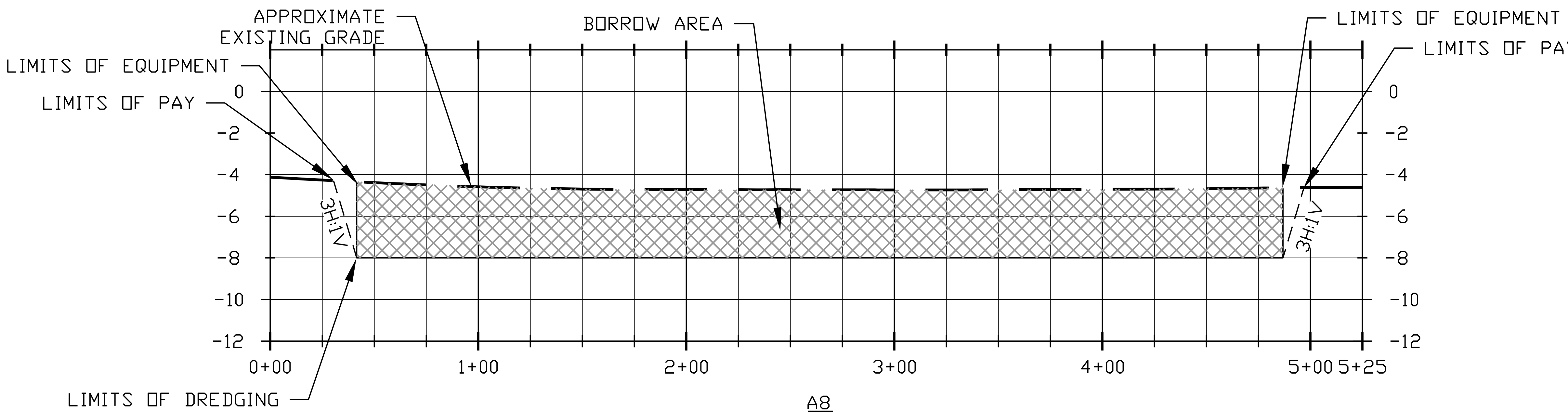
F&N JOB NO.	ADB20155
DATE	6/01/2023
SCALE	
DESIGNED	MLS
DRAFTED	RH
FILE	15-22 Borrow Area CS.dwg

FREESE NICHOLS
10431 Morado Circle, Suite 300
Austin, Texas 78759
Phone - (512) 617-3100
Web - www.freese.com

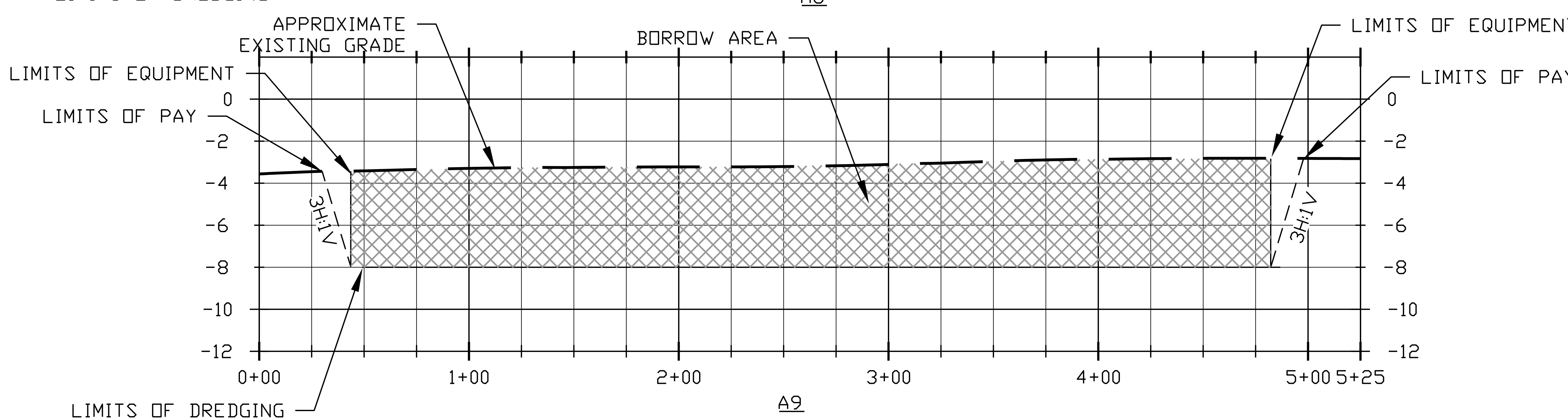
16
SHEET



A7



A8



A9

60' 0 60' 120'

HORIZONTAL SCALE: 1"=60'

10' 0 10' 20'

VERTICAL SCALE: 1"=10'

90% SUBMITTAL

THIS DOCUMENT IS RELEASED FOR THE PURPOSE OF INTERIM REVIEW UNDER THE AUTHORITY OF: MATT SALMON P.E. TEXAS NO: 143709 ON DATE: 6/01/2023 IT IS NOT TO BE USED FOR CONSTRUCTION, BIDDING OR PERMIT PURPOSES.

Freese and Nichols, Inc.
Texas Registered Engineering Firm F-2144

F&N JOB NO.	ADB20155
DATE	6/01/2023
SCALE	
DESIGNED	MLS
DRAFTED	RH
FILE	15-22 Borrow Area CS.dwg

AUDUBON TEXAS

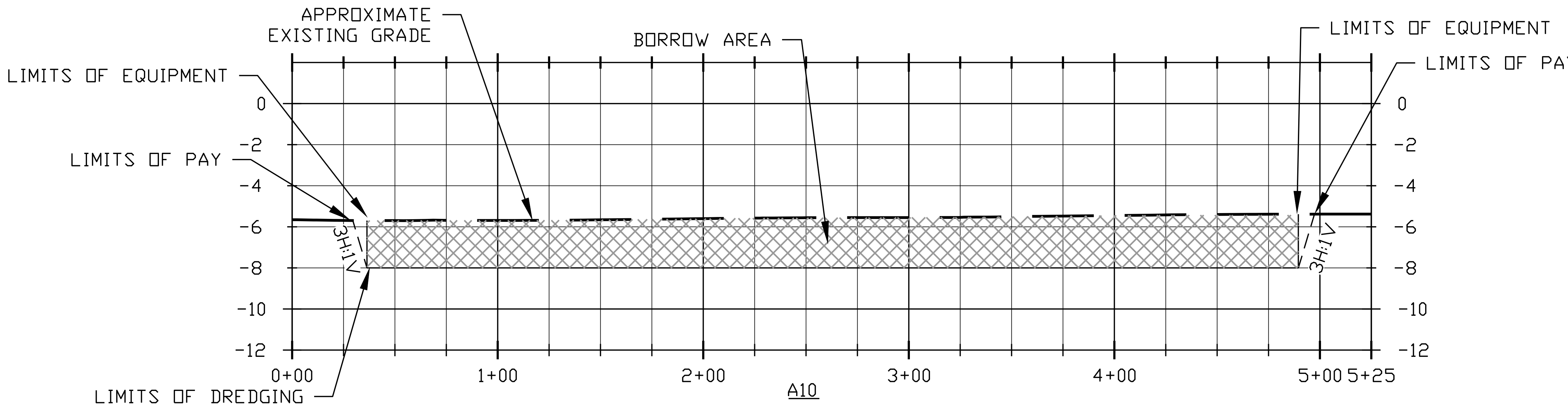
CARANCAHUA BAY MOUTH ROOKERY ISLAND

BORROW AREA CROSS SECTIONS

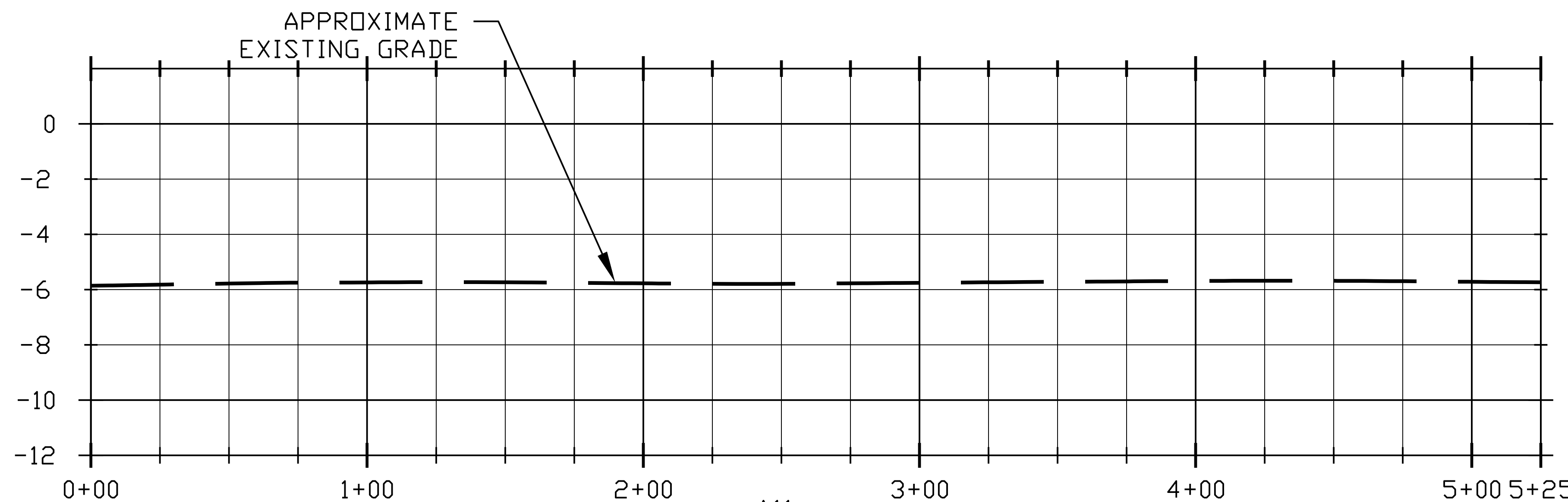
FREESE NICHOLS
10431 Morado Circle,
Suite 300
Austin, Texas 78759
Phone - (512) 617-3100
Web - www.freese.com

ACAD Rel: 23.0s (LMS Tech)
Filename: M:\A22-029 FNI-Bird Island (Texas)\CAD\15-22 Borrow Area CS.dwg
Last Saved: 5/15/2023 1:08 PM Saved By: Robin

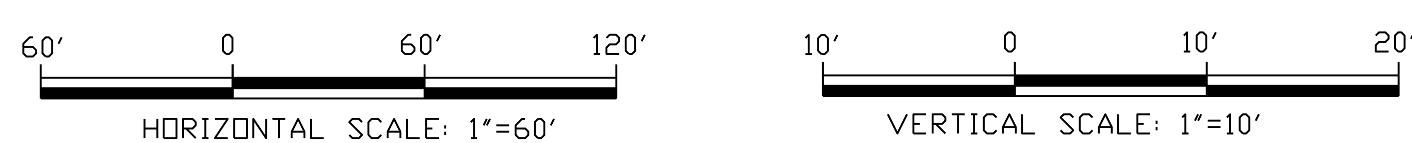
Plot Date: 6/1/2023 11:33 AM Plot By: Robin Filename: M:\A22-029 FNI-Bird Island (Texas)\CAD\15-22 Borrow Area CS.dwg



A10



A11



90% SUBMITTAL

THIS DOCUMENT IS RELEASED FOR THE PURPOSE OF INTERIM REVIEW UNDER THE AUTHORITY OF: MATT SALMON P.E. TEXAS NO: 143709 ON DATE: 6/01/2023 IT IS NOT TO BE USED FOR CONSTRUCTION, BIDDING OR PERMIT PURPOSES.

Freese and Nichols, Inc.
Texas Registered Engineering Firm F-2144

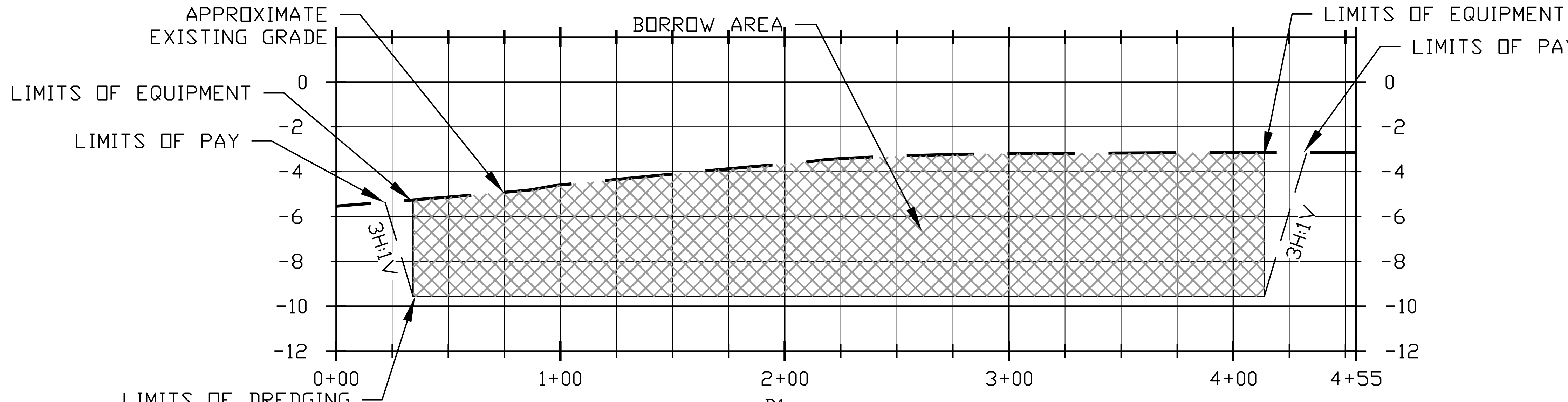
F&N JOB NO.	ADB20155
DATE	6/01/2023
SCALE	
DESIGNED	MLS
DRAFTED	RH
FILE	15-22 Borrow Area CS.dwg

AUDUBON TEXAS

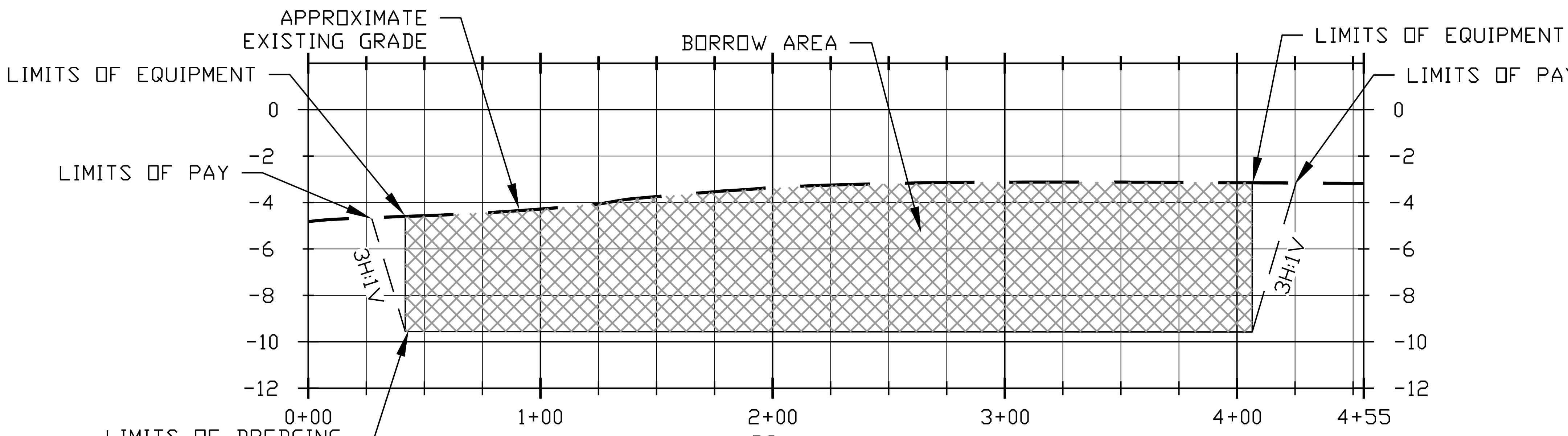
CARANCAHUA BAY MOUTH ROOKERY ISLAND

BORROW AREA CROSS SECTIONS

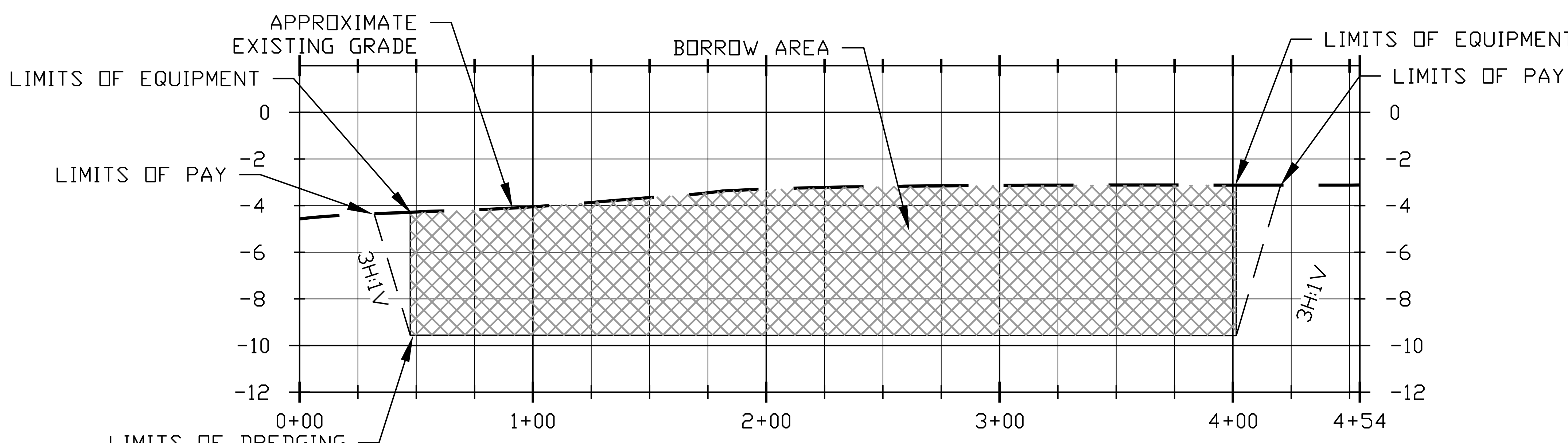
FREESE NICHOLS
10431 Morado Circle, Suite 300
Austin, Texas 78759
Phone - (512) 617-3100
Web - www.freese.com



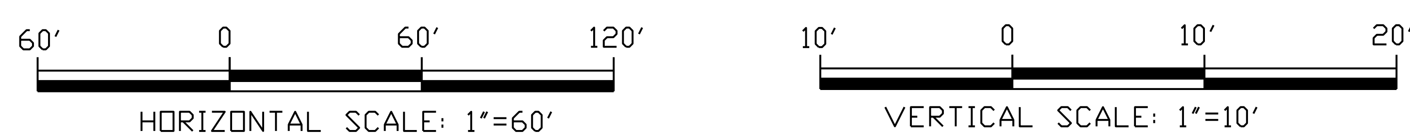
B1



B2



B3



90% SUBMITTAL

THIS DOCUMENT IS RELEASED FOR THE PURPOSE OF INTERIM REVIEW UNDER THE AUTHORITY OF: MATT SALMON P.E. TEXAS NO: 143709 ON DATE: 6/01/2023 IT IS NOT TO BE USED FOR CONSTRUCTION, BIDDING OR PERMIT PURPOSES.

Freese and Nichols, Inc.
Texas Registered Engineering Firm F-2144

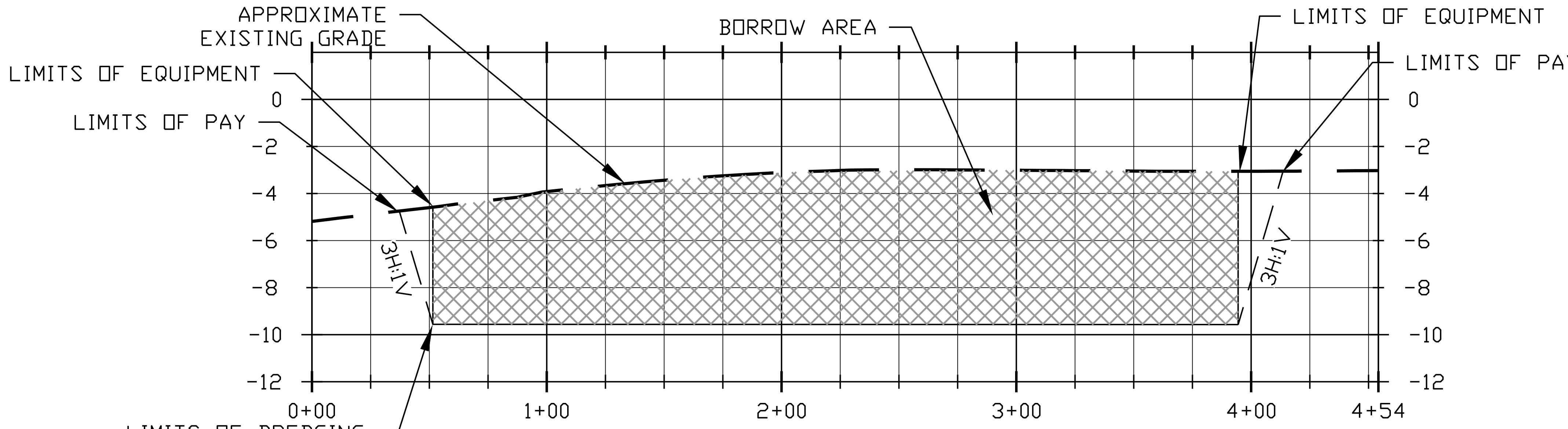
F&N JOB NO.	ADB20155
DATE	6/01/2023
SCALE	
DESIGNED	MLS
DRAFTED	RH
FILE	15-22 Borrow Area CS.dwg

AUDUBON TEXAS

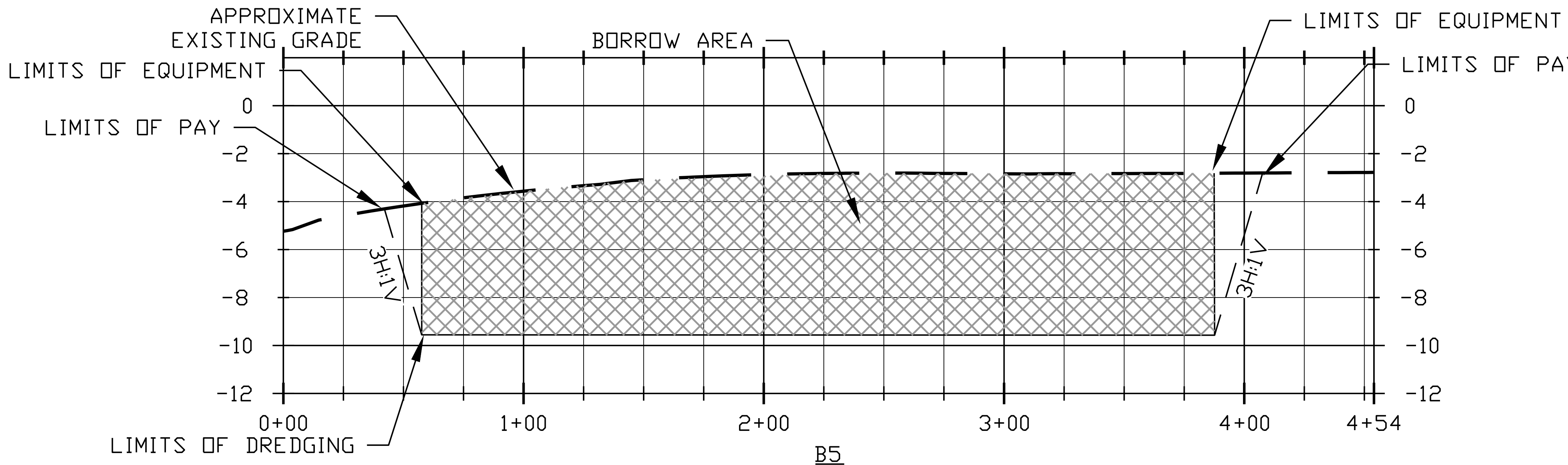
CARANCAHUA BAY MOUTH ROOKERY ISLAND

BORROW AREA CROSS SECTIONS

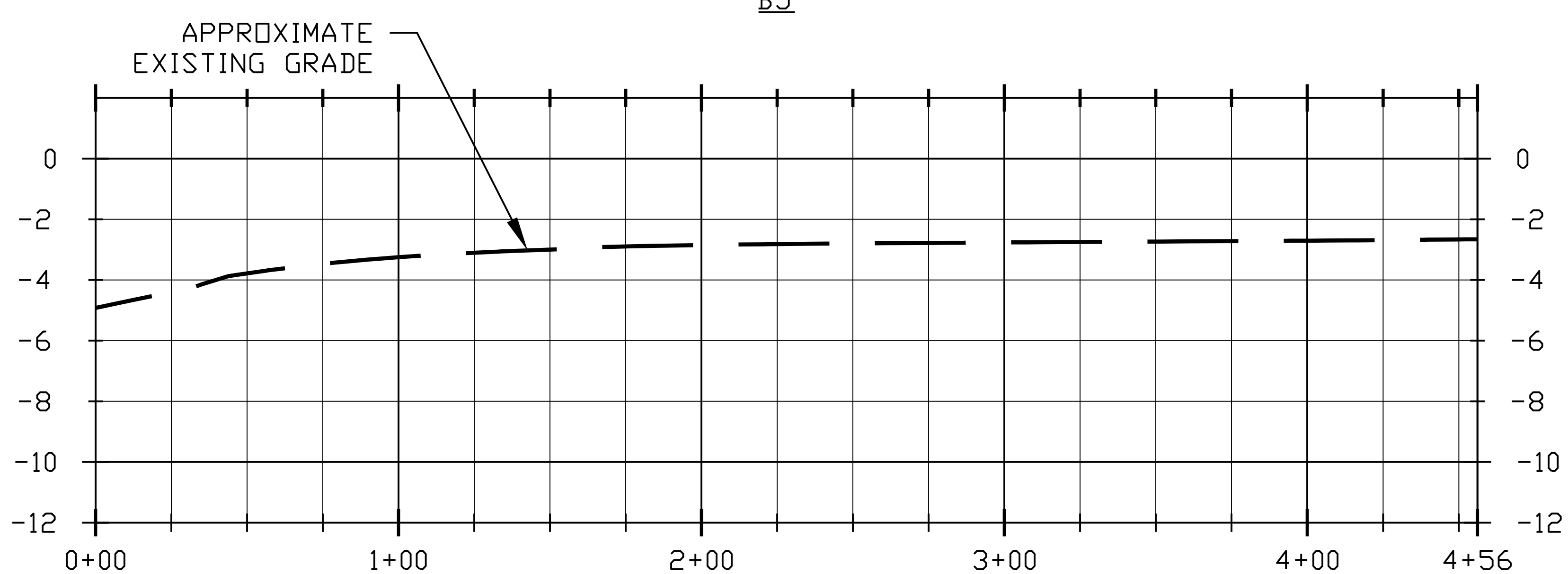
FREESE NICHOLS
10431 Morado Circle, Suite 300
Austin, Texas 78759
Phone - (512) 617-3100
Web - www.freese.com



B4



B5



B6

60' 0 60' 120'

HORIZONTAL SCALE: 1"=60'

10' 0 10' 20'

VERTICAL SCALE: 1"=10'

90% SUBMITTAL

THIS DOCUMENT IS RELEASED FOR THE PURPOSE OF INTERIM REVIEW UNDER THE AUTHORITY OF: MATT SALMON P.E. TEXAS NO: 143709 ON DATE: 6/01/2023 IT IS NOT TO BE USED FOR CONSTRUCTION, BIDDING OR PERMIT PURPOSES.

Freese and Nichols, Inc.
Texas Registered Engineering Firm F-2144

F&N JOB NO.	ADB20155
DATE	6/01/2023
SCALE	
DESIGNED	MLS
DRAFTED	RH
FILE	15-22 Borrow Area CS.dwg

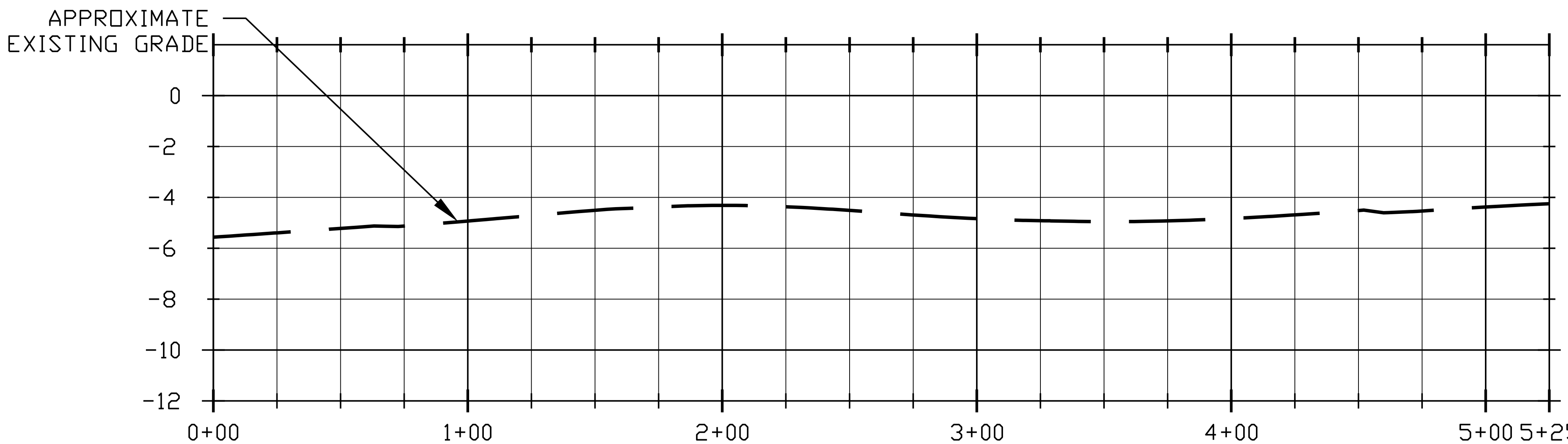
AUDUBON TEXAS

CARANCAHUA BAY MOUTH ROOKERY ISLAND

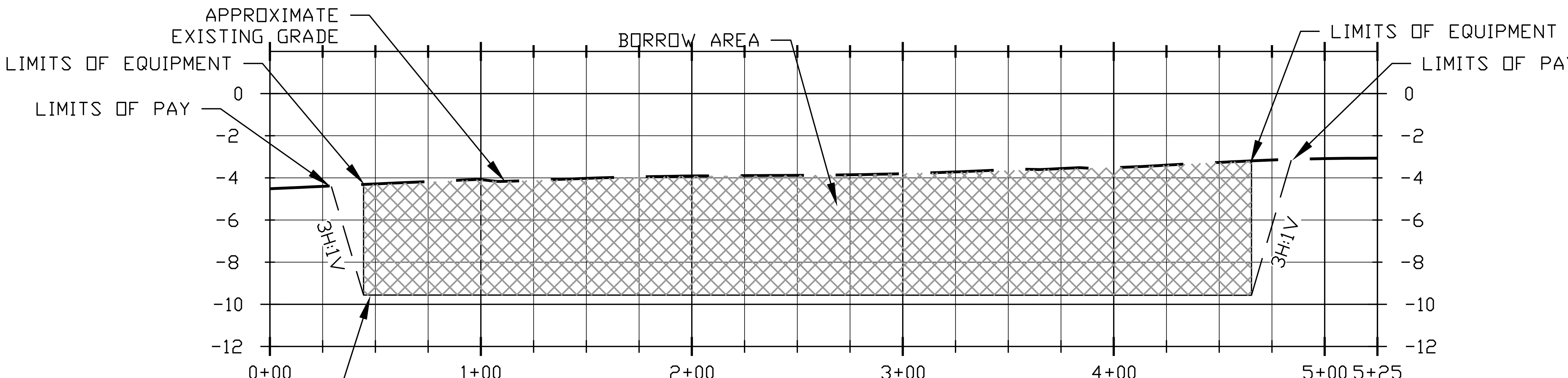
BORROW AREA CROSS SECTIONS

FREESE NICHOLS
10431 Morado Circle, Suite 300
Austin, Texas 78759
Phone - (512) 617-3100
Web - www.freese.com

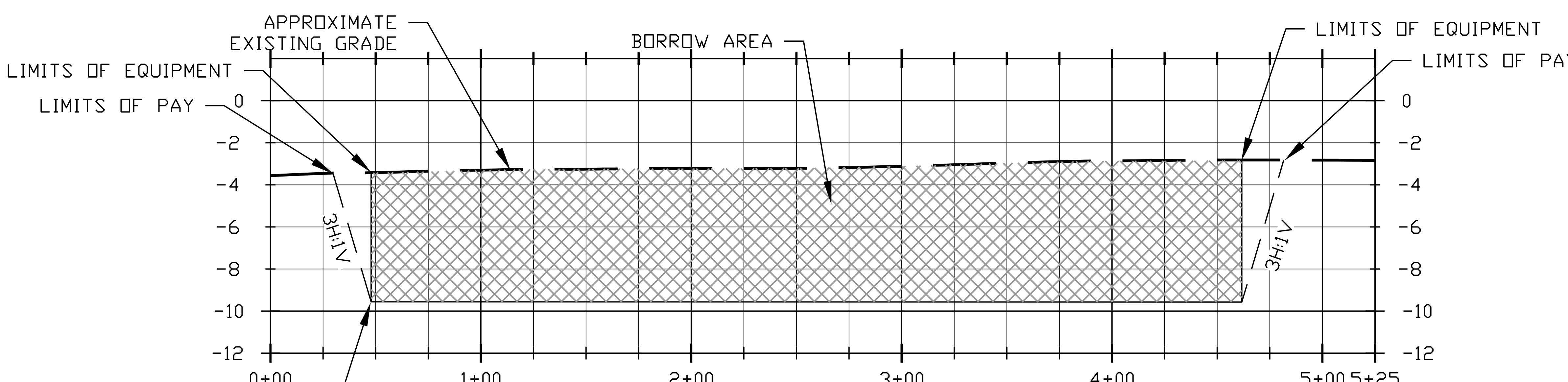
20
SHEET



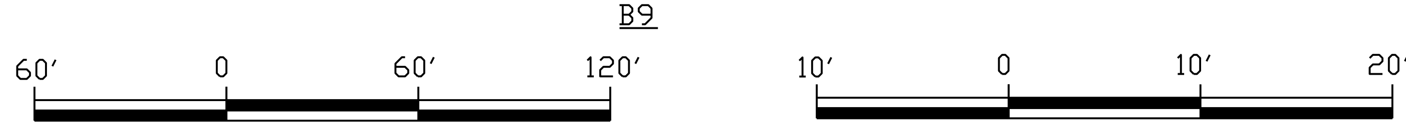
B7



B8



B9



HORIZONTAL SCALE: 1"=60'

VERTICAL SCALE: 1"=10'

90% SUBMITTAL

THIS DOCUMENT IS RELEASED FOR THE PURPOSE OF INTERIM REVIEW UNDER THE AUTHORITY OF: MATT SALMON P.E. TEXAS NO: 143709 ON DATE: 6/01/2023 IT IS NOT TO BE USED FOR CONSTRUCTION, BIDDING OR PERMIT PURPOSES.

Freese and Nichols, Inc.
Texas Registered Engineering Firm F-2144

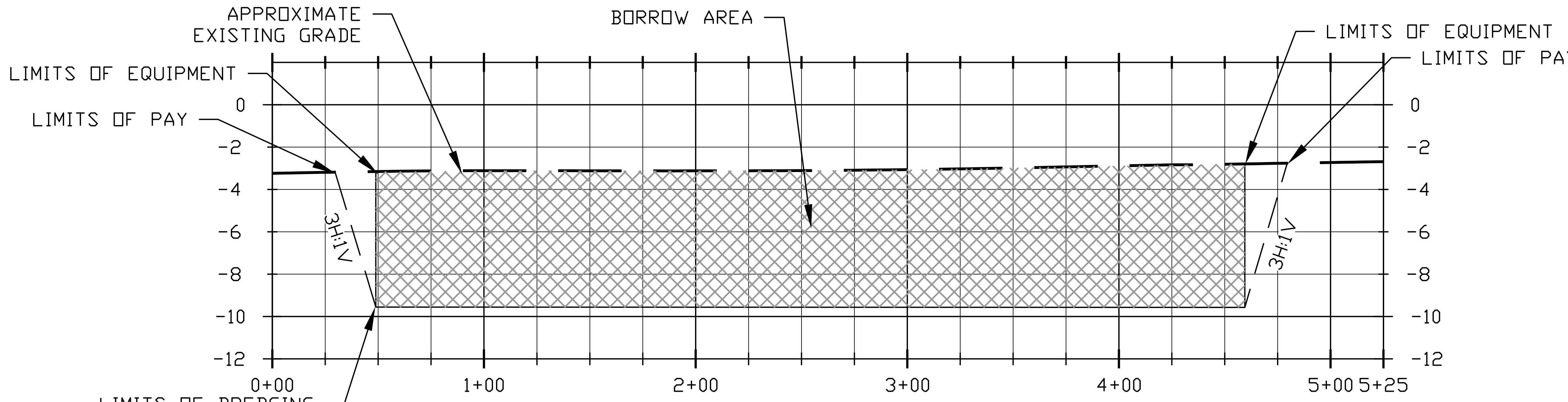
F&N JOB NO.	ADB20155
DATE	6/01/2023
SCALE	
DESIGNED	MLS
DRAFTED	RH
FILE	15-22 Borrow Area CS.dwg

AUDUBON TEXAS

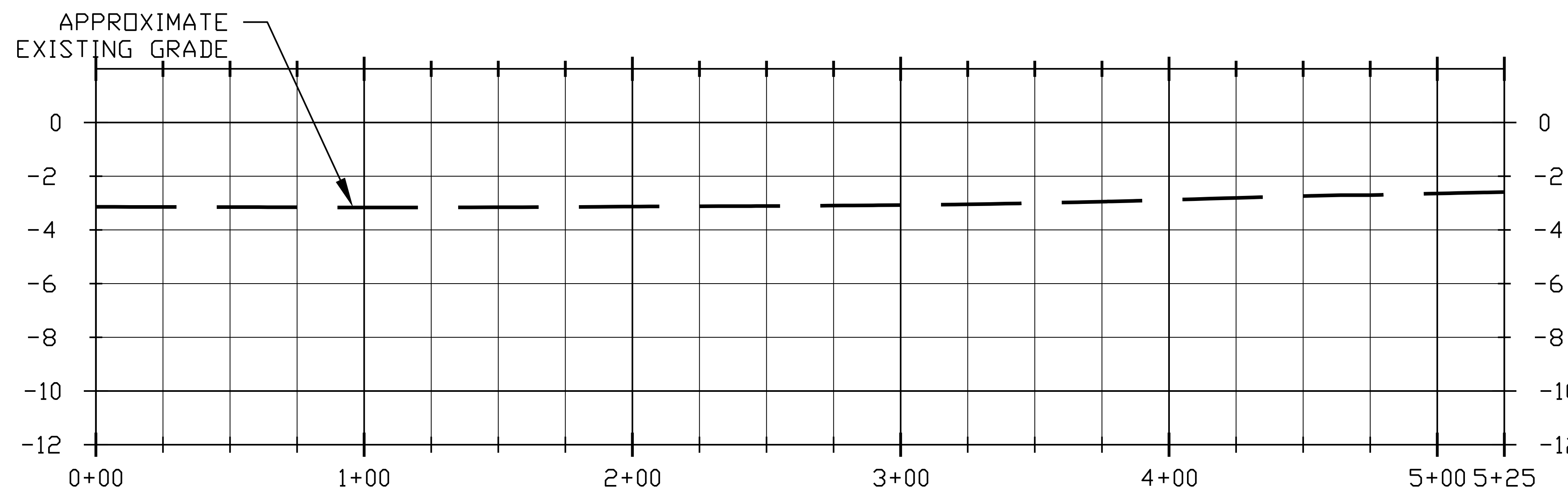
CARANCAHUA BAY MOUTH ROOKERY ISLAND

BORROW AREA CROSS SECTIONS

FREESE NICHOLS
10431 Morado Circle, Suite 300
Austin, Texas 78759
Phone - (512) 617-3100
Web - www.freese.com



B10



B11

60′ 0 60′ 120′
HORIZONTAL SCALE: 1″=60′

10′ 0 10′ 20′
VERTICAL SCALE: 1″=10′

90% SUBMITTAL
THIS DOCUMENT IS RELEASED FOR THE PURPOSE OF INTERIM REVIEW UNDER THE AUTHORITY OF: MATT SALMON P.E. TEXAS NO: 143709 ON DATE: 6/01/2023 IT IS NOT TO BE USED FOR CONSTRUCTION, BIDDING OR PERMIT PURPOSES.

Freese and Nichols, Inc.
Texas Registered Engineering Firm F-2144

F&N JOB NO. ADB20155
DATE 6/01/2023
SCALE
DESIGNED MLS
DRAFTED RH
FILE 15-22 Borrow Area CS.dwg

AUDUBON TEXAS
CARANCAHUA BAY MOUTH ROOKERY ISLAND
BORROW AREA CROSS SECTIONS

FREESE NICHOLS
10431 Morado Circle,
Suite 300
Austin, Texas 78759
Phone - (512) 617-3100
Web - www.freese.com

22
SHEET